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ABSTRACT

This articulation guide contains 17 units of instruction for the first year of a two-year vocational program designed to prepare the high school graduate to install, maintain, and repair various types of residential and commercial heating, air conditioning, and refrigeration equipment. The units are to introduce the student to fundamental theories and basic knowledge and skills and to prepare him/her for entry-level work as a helper. Introductory materials include descriptions of the first and second year courses and recommended secondary and postsecondary programs with postsecondary course descriptions. The seventeen units are entitled introduction; fundamentals of electricity; basic refrigeration; hand tools; heating, ventilation, and air conditioning (HVAC) benchwork with hand tools; special HVAC tools and equipment; HVAC test instruments; tubing; soldering; piping; electrical wire connections; wiring diagrams; electrical components; electric motors; domestic refrigeration servicing; install electrical outlet for window air conditioner; and room/window air conditioners. (Each unit contains some or all of these components: unit overview, minimum suggested terminology, task listings, and tasks. A task sheet for each task details performance objective, performance actions, performance standards, and related technical information. An addendum provides any additional materials needed to complete the task. (YLB)

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# ARTICULATED, PERFORMANCE-BASED INSTRUCTION OBJECTIVES GUIDE
# FOR
# AIR CONDITIONING, REFRIGERATION, AND HEATING
# (ENVIRONMENTAL CONTROL SYSTEM INSTALLER/SERVICER)

DEVELOPMENT PERIOD
JULY, 1983 - JUNE, 1984

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PREPARED BY
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REPRESENTING
THE SCHOOL DISTRICT OF GREENVILLE COUNTY
AND
GREENVILLE TECHNICAL COLLEGE
GREENVILLE, SOUTH CAROLINA

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JUNE, 1984
EDITION I

# ARTICULATED, PERFORMANCE-BASED CURRICULUM GUIDE

THE SCHOOL DISTRICT OF GREENVILLE COUNTY

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## ARTICULATION GUIDE

THE SCHOOL DISTRICT OF GREENVILLE COUNTY AND GREENVILLE TECHNICAL COLLEGE

THE SCHOOL DISTRICT OF GREENVILLE COUNTY
GREENVILLE, SOUTH CAROLINA

1984

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## ACKNOWLEDGEMENT

The Articulated, Performance-based Instruction Objectives Guide for Air Conditioning, Heating, and Refrigeration is the product of the work of the following instructor Task Force Committee participants representing the secondary programs of The School District of Greenville County and the post-secondary similar program at Greenvill Technical College.

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Articulated, performance-based instruction guides are developed based upon tasks (objectives) important to the success of entry level workers. The objectives are derived from task analysis and available tasks lists such as V-TEC Catalogs. Standards of performance are those expected by local businesses and industries for job success. Test samples are included to represent valid and reliable measures of vocational competency.

Articulated, performance-based instruction documents are designed to comply with the requirements of PL 94-482 Educational Amendments of 1976, Title II, which is intended to "...ensure that...curricula do not reflect sterotypes based upon sex, race, or national origin..."

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Many ideas and models, however, have evolved from years of research and experience and often are difficult to precisely credit.

The objectives and task actions of the articulated guides are developed or contributed by task force committee (instructor) participants based on their expertise and on task lists from resources such as V-TEC Catalogs. Standards included in guides are those identified by local potential employers as important to the success of entry level workers. Sample knowledge and performance tests are included to represent valid and reliable test items that may be used to measure mastery of objectives. Test samples taken from texts or workbooks typically are those being used locally and appropriate documentation has been included.

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Wm. Edward Henderson Jr., Coordinator
Occupational Education Articulation Program
The School District of Greenville County
and Greenville Technical College
1983

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# ABSTRACT

| | |
|---|---|
| Title of Program: | Occupational Education Articulation Program |
| Program Coordinator: | Wm. Edward Henderson Jr. |
| Sponsoring Agencies: | The School District of Greenville County<br>and Greenville Technical College<br>c/o P.O. Box 2848 - 301 Camperdown Way<br>Greenville, SC 29602 |
| Program Development Period: | July 1, 1983 through June 30, 1984 |

PURPOSE: To develop a continuous line of vocational training in similar Air Conditioning, Refrigeration, and Heating programs so that students may continue their career/vocational education at the secondary and post-secondary levels without loss of time or waste of effort in repeating tasks that have been mastered previously.

To provide a system where teachers can cooperate effectively in providing a continuous occupational development program where the level and type of training that leads to entry-level employment skills will be clear to students, teachers, other educators, and potential employers.

METHOD: Air Conditioning, Refrigeration, and Heating instructor representatives from the four secondary level career centers of The School District of Greenville County and the post-secondary level Air Conditioning, Refrigeration, and Heating Department Head from Greenville Technical College were brought together in task force committee meetings and workshops to survey very similar areas of vocational training to identify possible overlaps or gaps as students continue air conditioning, refrigeration, and heating training from the secondary level to the post-secondary level. In addition, lateral articulation of air conditioning, refrigeration, and heating programs at the secondary level was promoted.

This Articulated, Performance-based Instruction Objectives Guide for Air Conditioning, Refrigeration, and Heating, was developed by the Task Force Committee on Air Conditioning, Refrigeration, and Heating to facilitate articulation. The Task Force Committee, by the task analysis process, identified the minimum essential competencies for the secondary air conditioning, refrigeration, and heating graduate to continue training at the next higher level of labor market in the trade. Major objectives for competency were stated, performances to obtain the objectives were clarified, enabling actions were identified and placed in sequential order, instruction time was estimated, and performance standards were stated. Finally, outcome-referenced (criterion-referenced) measures of performance were developed as a guide in articulating (articulation).

RESULTS: As a result of the project development phase, the Articulated, Performance-based Instruction Objectives Guide for Air Conditioning, Refrigeration, and Heating was developed. This articulation guide, however, is not a final product since it must be field trial tested and revised. Modifications and improvements to the guide are expected since the process of education must be continually reviewed to ensure that objectives are valid and are being met as best they can be met under given conditions.

Prior to development of this articulation guide, an Articulation Policies and Procedures Guide was developed to aid articulation activities and was used to direct program and product (guide) development activities.

Workshop guides, developed and refined during an earlier phase of the program, were used to assist task force committee participants in obtaining task analysis data, writing performance-based objectives, identifying performance actions to reach the objectives, stating performance standards, and developing outcome-referenced tests. These how-to-do-it guides are usable at the instructional level as well as at the supervisory level.

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# PREFACE

This Articulated, Performance-based Instruction Objectives Guide is based on the following ASSUMPTIONS:

1. The grouping of tasks is more conducive to skill development in vocational education.

2. Potential employers probably would prefer an employee well educated in the basics with more detailed on-the-job training provided by the employer.

3. Among topics that should be included in vocational education are; saftey, career opportunities, how to get and keep a job, and the job attitudes that often are the key to employee success and job retention.

4. A premise of the articulated, performance-based instruction guide is that it is absolutely essential that career/vocational education/training be based on the knowledges, skills, abilities, and personal characteristics that are important to success on the job, if the vocational program is going to validly serve the needs of students and potential employers of the community.

5. Another premise in the articulated instruction guide is that vocational education can no longer be developed according to program titles, be time-based, lack flexibility, or overlook basic fundamentals if instruction is to meet the needs of students and employers and be of the highest quality.

6. Substantial research clearly indicates that instructional technology and accountability demands are increasing the movement toward the use of instructional systems.

   The systems approach, a method of organizing the instructional situation, methods, media, materials, and equipment so that the maximum knowledge and skill development may be achieved, is promoted because it directs its attention toward teaching the observable behaviors that the vocational student should possess at the termination of instruction.

   The instructional program described in this articulated, performance-based instructional objectives guide has been assembled by instructor task force committee participants representing The School District of Greenville County and Greenville Technical College and it is based on the concept that the minimum tasks described should be those identified for successful entry level employment according to local task analysis information, state-of-the-art literature, similar/related research/publications, and the expertise of the instructor participants.

7. The articulated instruction guide illustrates one way the (secondary) curriculm may be organized. The example is not intended to imply that there are not other ways to structure the curriculm.

The articulated instruction guide should be perceived as a vehicle to facilitate the development of alternate, detailed instructional plans for the individual learner.

8. While the objectives in this guide typically have been arranged in a sequence from less to more difficult in sequence of performance or as they might occur on the job, the tasks is not meant to indicate a required pattern.

9. The "suggested minimum instruction times" are included for planning purposes and may be extended as required for the completion of task objective. An underlying premise of the articulated instruction guide is that it is more desirable for the student to complete some objectives and gain some employable skills rather than to be introduced to a large number of tasks and not acquire any employable skills.

The actual amount of time required for each task objective may vary according to the local program objectives, the individual needs of the learner, the instructor, and the training facilities and materials available.

10. While it may become necessary to modify the vocational program from the articulated guide description, a lowering of the minimum standards (competency level) recommended by industry should be avoided to ensure that the program graduate can demonstrate a minimum performance essential to employment success.

11. This articulation guide was drafted in a period of less than twelve months so that a product production deadline of twelve months might be met.

Because of a restricted development time frame, emphasis was placed on developing a sound and valid articulation guide which might be refined at a later date.

Greenville, SC W.E.H.

# AIR CONDITIONING, REFRIGERATION, AND HEATING I

**LEVEL:** Seondary

**TITLE:** Air Conditioning, Refrigeration, and Heating I

**DESIGNATION:** Air Conditioning, Refrigeration, and Heating is a two year, vocational program designed to prepare the high school graduate to install maintain, and repair various types of residential and commercial heating, air conditioning, and refrigeration equipment.

During the first year of the program, the student is introduced to fundamental theories, shop and job safety, refrigeration/enviromental control tools and materials, basic and applied electricity, soldering, brazing, oxyacetylene welding, and compression systems. The student develops skills in tubing and fitting work and is introduced to electric motors.

**OBJECTIVE:** Upon successfully completing the first year of training, the Air Conditioning, Refrigeration, and Heating student will be able to assist the installer/serviceman by: (a) correctly using the terminology of the trade, (b) correctly using and caring for tools and materials, (c) reading basic schematics/drawings/diagrams, (d) cutting and drilling structural settings to receive systems, (e) lifting and positioning equipment, and (f) making basic electrical/mechanical/tubing connections, typically the job of the HELPER.

**PERFORMANCE EVALUATION:** To demonstrate competency in the knowledges and skills of Air Conditioning, Refrigeration, and Heating I, the student should be able to identify and correctly use and care for electrical, mechanical, refrigeration and heating tools; identify and correctly use and care for oxyacetylene welder, gas torches, and the electric soldering iron/gun; read and maintain various meters, checkers, gages, analyzers, and other instruments used in the field of air conditioning, refrigeration, and heating.

In addition, the air conditioning student should be able to interpet and apply safety procedures, respond to emergency situations, demonstrate ladder safety, interpret and apply safe lifting techniques, select and wear safety apparel and accessories, interpret and use fire safety procedures including being able to operate and maintain fire extinguishers.

The student should be able to locate and interpret applicable electrical, plumbing, mechanical, and other building codes; read and interpret electrical symbols, ladder diagrams, schematics, valves and loads; read and interpret blueprints, mechanical and chemical symbols, refrigerant tables, pnenuatic diagrams, as well as to identify various types of refrigerants, determine the chemical make up of refrigerants, and identify and apply various types of lubricants.

In addition, the air conditioning student should be able to identify types of duck work material; perform light carpentry duties; assist in the installation of equipment, in the troubleshooting and servicing of equipment and systems and service control systems; and, on the job, display punctuality, listen, demonstrate patience on the job, take and follow instructions, work with fellow employees, and project a positive self image through dress, grroming, posture, and hygiene.

PREREQUISITES: None

Suggested Grade Level: 11

RECOMMENDED PREPARATION: Course which should prove helpful to the secondary student entering air conditioning, refrigeration, and heating training include; general mathematics, physical science, mechanical drawing, prevocation, and industrial arts.

A first year student should be able to make extremely accurate linear, fractional measurements and to perform a variety of job math computations.

The student must be able to read and follow technical procedure sheets, manufacturer's manuals, and diagnostic equipment measurements in testing parts and equipment.

REQUIRED INSTRUCTION HOURS:

| Systems Division | Year Class/Lab |
|---|---|
| Credits | 3 |
| Hours | 540 |

LEVEL: Seondary

TITLE: Air Conditioning, Refrigeration, Heating II

DESIGNATION: AIR COND REF HEATING II COMPUTER NUMBER 742

DESCRIPTION: The second year of Air Conditioning, Refrigeration, Heating will help the student to expand and apply the basic knowledges and skills mastered during the first year of training as well as learning new principles and techniques in the installation, maintenance, and repair or residential and commercial/industrial systems.

The second year student will learn the basic operation, installation, and maintenance of electric motors and controls, pipe installations, heat pumps, oil and gas furnaces, hydronics and solar systems, shop and job safety and customer relations. The student will be introduced to calculating heating loads as well as to servicing automotive air conditioners.

OBJECTIVE: The two year, secondary level Air Conditioning, Refrigeration, and Heating vocational program is designed to prepare the graduate for successful entry into employment in the field of installing, maintaining, or servicing environmental control systems and units as well as related equipment/systems, refrigeration systems, and small heating units, etc.

Typical entry level work will be the installation and service field as an APPRENTICE.

PERFORMANCE EVALUATION: Upon successfully completing Air Conditioning, Refrigeration, Heating II, the graduate should be able to operate and maintain tools and test equipment; interpret and apply safety procedures; interpret and apply codes; read and interpret charts, drawings, and schematics; install equipment such as air handling, condensing, and evaporating units as well as heat pumps, motors, solar systems, coolers, and freezers.

The graduate should be able to install electric, gas, and oil heating systems; electronic air filters; cooling towers; as well as special environmental systems and equipment associated with hospital, restaurant, or industrial/business settings.

The graduate should be able to troubleshoot and service equipment and systems; and install, troubleshoot and service control systems. In addition, the graduate should be able to estimate job requirements and the cost of jobs, interpret various technical formulas and apply them to a variety of practical situations; to solve technical problems encountered in the installation, maintenance, or repair of systems; and to apply personal business competencies including effective communications.

PREREQUISITES: Air Conditioning, Refrigeration, and Heating I

Suggested Grade Level: 12

REQUIRED INSTRUCTION HOURS:

| | |
|---|---|
| System | Year |
| Division | Class/Lab |
| Credits | 3 |
| Hours | 540 |

TOTAL REQUIRED INSTRUCTION HOURS FOR SECONDARY LEVEL PROGRAM:

| | |
|---|---|
| System | Year |
| Division | Class/Lab |
| Credits | 6 |
| Hours | 1,080 |

WORKING CONDITIONS: The Air Conditioning, Refrigeration, and Heating mechanic should like to work without supervision, independently, with responsibility in a variety of settings and doing many different tasks. The mechanic should be prepared to drive a truck from job to job and work with machines and tools.

For optimum success in the air conditioning, refrigeration, and heating field, the mechanic should be able to: use logical step-by-step procedures to complete tasks, accurately read a variety of testing devices and gages, read directions and follow instructions, and explain the operation and care of equipment to customers. In addition, the mechanic should be prepared to make estimates, bills, keep records, etc. Work often will require making emergency visits at odd hours of the day.

The mechanic should be able to coordinate the movement of fingers, hands, and arms and be able to manipulate hand tools and small parts.

EMPLOYMENT OPPORTUNITIES: The Air Conditioning, Refrigeration, and Heating program is designed primarily to prepare graduates for entry level employment to install, maintain, and repair air conditioning, refrigeration and heating equipment in a variety of settings such as residences, businesses, industries, hospitals, etc.

Typical job opportunities might include:

Refrigeration Mechanic Helper, D.O.T. 637.687-014
Refrigeration Unit Repairer, D.O.T. 637.381-014
Refrigeration Mechanic, D.O.T. 637.261-026

Environmental-Control System Installer-Servicer Helper, D.O.T. 637.664-010
Environmental-Control System Installer Servicer, D.O.T. 637.261-014

Furnace Installer, D.O.T. 862.361-010
Oil Burner Mechanic. D.O.T. 862.281-018
Gas Burner Mechanic, D.O.T. 637.261-018

Additional job opportunities may be found in installation/service work with gas and power companies, in appliance installation and service work, and a variety of related businesses.

Because of the increasing use of solid state electronic circuitry such as variable speed controls, integrated circuit control and timing systems, digital and computer monitors and controls, the high school graduate should consider seriously further career preparation at the post-secondary level in the related Greenville Technical College program.

EMPLOYMENT PROJECTION:

According to South Carolina Employment Security Commission projections, the Air Conditioning, Heating and Refrigeration field will see a 9.8 percent change between 1978 and 1985 and a growth of approximately 10 additional positions between 1983 and 1985 with the projected 1985 employment in the Greenville-Spartanburg area expected to be around 560 mechanics. This number, however, may not fully represent the number of practicing self-employment air conditioning, refrigeration, and heating mechanics or those successfully employed in related fields.

South Carolina Occupational Projections, 1978-1985, Columbia, SC: South Carolina Employment Security Commission (Research & Analysis Department), p. 185, 1982.

| | |
|---|---|
| JOURNEYMAN LICENSING: | Generally, the high school graduate will enter employment as an apprentice working toward trade certification particular to the work. Apprenticeships typically are four years. |
| SERVICE & INSTALLATION JOURNEYMAN, LIMITED: | The Journeyman with a Limited License may install, alter, or service self-contained room units and domestic refrigerators, not exceeding 1 1/2 horsepower, providing the work is supervised by a licensed contractor employing the journeyman. The applicant must have been actively engaged in such work for at least two years or for one year if he is a graduate of an approved Refrigeration Trade School or holds a First Class Refrigeration Operator's License. |
| SERVICE & INSTALLATION JOURNEYMAN, UNLIMITED: | The journeyman with an Unlimited License may install, alter, or service any refrigeration equipment covered by the license of the refrigeration contractor by whom he is employed. The applicant shall have at least four years of experience or at least two years if he is a graduate of an approved Refrigeration Trade School or holds a First Class Refrigeration Operator's License. |

## SECONDARY LEVEL
## STATE DEPARTMENT OF EDUCATION
## RECOMMENDED PROGRAM

### Air Conditioning and Refrigeration

The SC State Department of Education describes Air Conditioning and Refrigeration as a constantly changing technology serving residential, commercial, and industrial situations. Air Conditioning and Refrigeration program students receive training to prepare them for entry work in the manufacturing, installation, and service of various types of residential and commercial environmental control systems.

The two year secondary program is designed to develop the knowledges, skills, and attitude inportant to success as a mechanic in the air conditioning and refrigeration field. Graduates of the program have received a sound theoritical base as well as practical applications so they know the hows and whys of troubleshooting and servicing of small to large air conditioning and refrigeration systems. The program includes a sub-course on heating featuring heat pumps, oil and gas heating systems, automatic controls, and duct work.

Topics suggested by the SC State Department of Education include, but need not be limited to:

1. Safety
2. Blueprint reading
3. Fundamentals of refrigeration
4. Test equipment, tools, and materials
5. Compressors
6. Refrigerants and controls
7. Electricity
8. Motors and automatic controls
9. Evaporators and condensors
10. Domestic refrigeration
11. Commercial refrigeration
12. Air conditioning principles
13. Air conditioning systems and controls
14. Automotive air conditioning
15. Welding
16. Estimating

Outline of High School Credit Courses, Columbia, SC: SC State Department fo Education, p. 124 (locally edited and updated).

Defined Minimum Program for South Carolina School Districts. Columbia, SC: S.C. Department of Education, 1980.

## POST-SECONDARY DESCRIPTION
## GREENVILLE TECHNICAL COLLEGE

### Air Conditioning/Refrigeration Mechanic
### and
### Climate Control Technology

"The Air Conditioning/Refrigeration Mechanic Curriculum is designed to supply the students with technical information and skills to enable the student to enter the fields of service and installation of air conditioning, refrigeration or heating. Upon completion of the one year courses, the students may graduate with a diploma in Air Conditioning/Refrigeration Mechanic or continue their career preparation an additional three quarters and receive an Associate Degree in Climate Control Technology. The additional year of training will enable the graduate to seek employment in the design of systems--leading into a supervisory position or self-employment."

Suggested Sequence of Required Courses:

FIRST QUARTER

| COURSE NUMBER | COURSE TITLE | CLASS | LAB | CREDIT |
|---|---|---|---|---|
| ACR 105 | Refrigeration Fundamentals | 5 | 9 | 8 |
| ACR 116 | Basic Electricity | 5 | 3 | 6 |
| ENG 150 | Introduction to Composition | 4.5 | 0 | 4.5 |
| | | 14.5 | 12 | 18.5 |

SECOND QUARTER

| COURSE NUMBER | COURSE TITLE | CLASS | LAB | CREDIT |
|---|---|---|---|---|
| ACR 121 | Installation & Service of Refrigeration Systems | 3 | 9 | 6 |
| ACR 137 | Automatic Controls | 4 | 3 | 5 |
| ACR 190 | Employee Development | 3 | 0 | 3 |
| EGT 100 | Blueprint Reading & Sketching | 3 | 0 | 3 |
| | | 13 | 12 | 17 |

THIRD QUARTER

| COURSE NUMBER | COURSE TITLE | CLASS | LAB | CREDIT |
|---|---|---|---|---|
| ACR 110 | Heating Fundamentals | 4 | 6 | 6 |
| ACR 166 | Heat Pump | 4 | 3 | 6 |
| WLD 111 | Gas Welding | 1 | 3 | 2 |
| MAT 112 | Applied Math | 5 | 0 | 5 |
| | | 14 | 12 | 18 |

FOURTH QUARTER

| COURSE NUMBER | COURSE TITLE | CLASS | LAB | CREDIT |
|---|---|---|---|---|
| ACR 136 | Air Conditioning I | 4 | 6 | 6 |
| ACR 140 | Gas Heating | 4 | 3 | 5 |
| ACR 146 | Building Codes & Ordinances | 3 | 0 | 3 |
| ECO 100 | Consumer Economics | 3 | 0 | 3 |
| | | 14 | 9 | 17 |

# CLIMATE CONTROL TECHNOLOGY

Suggested Sequence of Required Courses:

## FIFTH QUARTER

| COURSE NUMBER | COURSE TITLE | CLASS | LAB | CREDIT |
|---|---|---|---|---|
| ACR 122 | Principles of Air Conditioning | 6 | 3 | 7 |
| ACR 203 | Advanced Controls | 5 | 3 | 6 |
| MAT 122 | Applied Math II | 5 | 0 | 5 |
| | | 16 | 6 | 18 |

## SIXTH QUARTER

| | | | | |
|---|---|---|---|---|
| ACR 202 | Advanced Air Conditioning | 5 | 3 | 6 |
| ENG 236 | Advanced Technical Composition & Communications | 4.5 | 0 | 4.5 |
| Elective(s): 5-8 Credits; For Example: | | | | |
| ACR 152 | Industrial Controls | 5 | 3 | 6 |
| | | 14.5 | 6 | 16.5 |

## SEVENTH QUARTER

| | | | | |
|---|---|---|---|---|
| ACR 201 | Advanced Refrigeration | 5 | 3 | 6 |
| ACR 204 | Conversion of Solar Energy for Climate Control | 4 | 0 | 4 |
| Elective(s): 5-8 Credits; For Example: | | | | |
| ACR 215 | Testing and Balancing | 5 | 3 | 6 |
| | | 14 | 6 | 16 |

## ELECTIVES

| | | | | |
|---|---|---|---|---|
| ACR 152 | Industrial Controls | 5 | 3 | 6 |
| ACR 215 | Testing and Balancing | 5 | 3 | 6 |
| ACR 165 | Hydronic Systems | 4 | 3 | 5 |
| EGT 110 | Mechanical Drawing | 2 | 3 | 3 |
| EGT 151 | Industrial Drafting | 5 | 0 | 5 |

Source: Catalog, Industrial Division, Greenville Technical College, 1982-1984, Greenville, SC: Greenville Technical College, pp. 2-3.

Air Conditioning/Refrigeration Department, GTC

## FIRST QUARTER

### ACR 116 BASIC ELECTRICITY:

A basic course of study in all phases of electricity beginning with electron theory and progressing to diagnosing electrical circuits. This will include the principle of conductors, insulators, and resistors. You will study volts, amperage, Ohms Law, series/parallel/series - parallel circuits in alternating and direct current. You will learn about magnetism, inductance, capacitance and the principles on which they work. You will wire electrical circuits and learn to troubleshoot them, along with the study of electrical measuring devices such as the volt, ohm, and ammeters. Prerequisite: ENG 117 (5-3-6)

### ACR 105 REFRIGERATION FUNDAMENTALS:

An introduction to the principles of refrigeration, terminology, the use and care of tools and equipment, and the identification and function of the component parts of a system. This study will include the basic laws of refrigeration; characteristics and comparisons of the various refrigerants. Practical work includes compressor assembly and disassembly, tube bending, flaring and soldering along with the construction of a small refrigeration cycle. Prerequisite: ACR 116 (5-9-8)

### ENG 150 INTRODUCTION TO COMPOSITION:

A study and application of the principles of grammar, mechanics, and rhetroic as preparation for business and technical writing. The course will include writing correct and effective paragraphs and essays of various types, including expository, narrative, and descriptive. (4.5-0-4.5)

## SECOND QUARTER

### ACR 137 AUTOMATIC CONTROLS:

A study of electrical controls for air conditioning and refrigeration. The student will be able to install and service these controls. Prerequisite: ACR 116 (4-3-5)

### ACR 121 INSTALLATION & SERVICE OF REFRIGERATION SYSTEMS:

A study of the design, characteristics, components, operation, servicing, troubleshooting and repair of mechanical refrigeration systems to include reach-in and walk-in cooling and freezing cabinets, display cases, ice machines and water coolers. The student will possess the knowledge and skills to service, troubleshoot and repair commercial and domestic mechanical refrigeration systems using the necessary test instruments and tools. Prerequisites: ACR 105 and 137 (3-9-6)

### ACR 190 EMPLOYEE DEVELOPMENT:

An attempt to motivate the student in self-appraisal and prepare the student for good relations with employers, customers, and fellow workers. Members of the Advisory Committee and others from industry will be used in presenting specific examples of business situations. (3-0-3)

### EGT 100 BLUEPRINT READING & SKETCHING:

A study of basic blueprint reading and sketching. It includes a detailed study of layout, projection, and dimensioning. The student completing this course should be able to make sketches of certain geometric shapes and be able to orthographically project these shapes. He/she should be able to read and interpret shop drawings, and should be familiar with the most common drawing instruments. (3-0-3)

## THIRD QUARTER

### ACR 110 HEATING FUNDAMENTALS:

A study of the design, construction and operation of oil and gas fired heating systems along with their accessory components. You will learn the sequence of operation and performance of each part and control in the system. You will be able to diagnose system malfunctions quickly and efficiently. You will test burners for proper efficiency through the use of combustion test equipment, and be able to make the necessary adjustments. You will perform the steps in starting up a system along with making all the related wiring connections. Prerequisite: ACR 116 (4-6-6)

### ACR 166 HEAT PUMP:

Will cover the principles of heat transfer as first conceived by Lord Kelvin in 1852. These principles will than be applied to the present day reverse cycle machiner. The mechanical and electrical devices, coil design and air flow characteristics will be presented and demonstrated in detail. Prerequisites: ACR 105 and 137 (4-3-5)

### WLD 111 GAS WELDING:

The student will be familiar with the principles and procedures for oxyacetylene welding in the four basic positions, flame cutting bronze welding, brazing and silver brazing, correct handling of welding equipment, and safe shop practices. (1-3-2)

### MAT 112 APPLIED MATH:

Review of basic operations of arithmetic and an introduction to elementary algebra through linear equations in one unknown. Industrial applications. Prerequisite: Satisfactory score on math placement test. (5-0-5)

FOURTH QUARTER

ACR 136 AIR CONDITIONING I:

The student will be introduced to various types of air conditioning systems and will learn how to properly install and service them. He/she will utilize the knowledge gained on charging systems using proper procedures for replacing components. Prerequisites: ACR 137 and 122. (4-6-6)

ACR 140 GAS HEATING:

This course is designed to provide installation and service knowledge on all types of gas fired equipment, including furnances, boilers, unit heaters, etc., as used in the heating and air conditioning industry. The student will learn to use the necessary tools, test instruments and proper procedures. He/she will learn to make the necessary adjustments on the burners and controls. Prerequisite: ACR 116. (4-3-5)

ACR 146 BUILDING CODES & ORDINANCES:

A study of the various codes and ordinances governing air conditioning and refrigeration locally and nationally. (3-0-3)

ECO 100 CONSUMER ECONOMICS:

Emphasizes the role of the consumer in our society. It includes consumer decision making, money and marital happiness, money management, consumer credit, intelligent shopping, financing a home, transportation, health services, estate planning, and consumer protection. (3-0-3)

## CLIMATE CONTROL TECHNOLOGY

FIFTH QUARTER

ACR 122 PRINCIPLES OF AIR CONDITIONING:

A study of the air cycle, psychrometrics, load estimating and air distribution. The student will design a small air conditioning system. Prerequisites: ACR 115, MAT 112, and EGT 100 (6-3-7)

ACR 203 ADVANCED AUTOMATIC CONTROLS:

An in-depth study of all types of automatic controls as they relate to residential and commercial applications. The student will design a control system that will control heating, cooling, humidification, and air cleaners in a residential system. The student will design a control system as it pertains to commercial boilers, chillers, ventilators, air handlers, towers, condensing units and their related accessories. Prerequisite: ACR 137. (5-3-6)

MAT 122 APPLIED MATH II:

Continuation of elementary algebra through quadratic equations. Elementary plane and solid geometry. Industry applications. Prerequisite: MAT 112. (5-0-5)

## SIXTH QUARTER

ACR 202 ADVANCED AIR CONDITIONING SYSTEMS:

A study in selection and design of air conditioning systems beginning with smaller tonnage units and progressing into large commercial systems. The student will learn to match and select equipment compatible to the demands of a structure. He/she will learn installation and service methods as they pertain to air and water cooled equipment. He/she will study equipment capacities and characteristics from manufacturers' products data and how they relate to a given application. Prerequisite: ACR 136. (5-3-6)

ENG 236 ADVANCED TECHNICAL COMPOSITION & COMMUNICATIONS:

Instruction in the theory and practice of planning and writing effective business and technical compositions. A research project reflecting acceptable writing styles and basic knowledge of the student's major area of study is required. Techniques of oral communication and presentations will be covered. Prerequisite: ENG 150. (4.5-0-4.5)

ACR 152 INDUSTRIAL CONTROLS:

This is a study of commercial and industrial control theory and fundamentals along with their practical use. The student will study pneumatic systems, power elements. linkages, valves and dampers, fluid controls and actuators. Prerequisite: ACR 203. (5-3-6)

## SEVENTH QUARTER

ACR 201 ADVANCED REFRIGERATION:

A study in the selection and design of various commercial and domestic refrigeration units. The student will learn to select coils and condensing units to match the calculated demands of any type of system. He/she will learn installation and service methods as they pertain to various systems. He/she will study equipment capacities and characteristics of refrigerated items such as meat, vegetables, etc. Prerequisite: ACR 120. (5-3-6)

ACR 204 CONVERSION OF SOLAR ENERGY FOR CLIMATE CONTROL:

A basic study in the collection and storage of solar energy including the various basic heating systems and components. The student will learn how to measure the energy collected and how to transfer heat to storage areas for future use. (4-0-4)

ACR 215 TESTING AND BALANCING:

This is a study of testing and balancing air and water quanities in heating and air conditioning duct work and piping. The student will learn to work with air quantities, temperatures, humidity control and testing the overall stability of a system. He/she will work with, and learn to use, basic instruments for testing and balancing heating and air conditioning systems. Prerequisite: ACR 202. (5-3-6)

ELECTIVES:

ACR 152 INDUSTRIAL CONTROLS:

This is a study of commerical and industrial control theory and fundamentals along with their practical use. The student will study pneumatic systems, power elements, linkages, valves and dampers, fluid controls and actuators. Prerequisite: ACR 203. (5-3-6)

ACR 215 TESTING AND BALANCING:

This is a study of testing and balancing air and water quantities in heating and air conditioning duct work and piping. The student will learn to work with air quantities, temperatures, humidity control and testing the overall stability of a system. He/she will work with, and learn to use, basic instruments for testing and balancing heating and air conditioning systems. Prerequisite: ACR 202. (5-3-6)

ACR 165 HYDRONIC SYSTEMS:

A study of hot and chilled water plus steam systems fueled by gas, oil, solar and/or electricity. The student will design a piping system carrying steam and/or water along with appropriate controls. Prerequisites: ACR 105, 110, and 137. (4-3-5)

EGT 110 MECHANICAL DRAWING I:

An introduction to principles and practices of mechanical drafting, which includes a study of instrument drawing, technical lettering, geometrical construction, orthographic projection of normal, inclined, oblique, and cylindrical surfaces, and principles for selection and use of size and location dimension. (0-6-2)

EGT 151 INDUSTRIAL DRAFTING:

A course of study designed to prepare students to complete orthographic descriptions of complex objects. Special practices will include auxiliary and sectional views. Dimensioning, note, limits, and precision practices and screw threads and fasteners will be studied as they relate to preparation of design, detail, assembly, production and construction drawings. (5-0-5)

# AIR CONDITIONING, REFRIGERATION, AND HEATING

## FIRST YEAR

(Secondary Level)

HVAC - The abbreviation, HVAC, is used in this guide to represent Heating-Ventilation-Air Conditioning (including refrigeration). The abbreviation H/AC/REF (Heating-Air Conditioning-Refrigeration) is acceptable also.

# UNIT 1.0

Unit 1.0, Introduction/Orientation, has been designed to represent introductory requirements of the vocational program such as course policies, procedures, and safety regulations; leadership training; desirable work attitudes and habits that potential employers recommend be incorporated in secondary instruction; career information; and basic math and related skills necessary for success in the vocation.

Some task objectives that are described in this first unit naturally will be learned early in the instructional program while competencies in other tasks may result during the first year or second year. For example, students must understand the policies of the program very early in the first year but may not develop competencies in job attitudes or career information until the second year. Job habits and attitudes typically will be taught during the entire two year training program.

Unit 1.0 is divided into the following topics:

| | |
|---|---|
| UNIT 1.0 A | INTRODUCTION/ORIENTATION |
| UNIT 1.0 B | INTRODUCTION TO SAFETY |
| UNIT 1.0 C | INTRODUCTION TO LEADERSHIP/JOB COMMUNICATIONS |
| UNIT 1.0 D | PREPARING FOR WORK |
| UNIT 1.0 E | INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/HABITS/ATTITUDES |
| UNIT 1.0 F | BASIC MATH SKILLS |
| UNIT 1.0 G | BASIC MEASURING |
| UNIT 1.0 H | WRITE AND READ TECHNICAL INFORMATION |

## AIR CONDITIONING, REFRIGERATION, HEATING
## INTRODUCTION
## SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 1.0 A | INTRODUCTION/ORIENTATION | |
| 1.01 | Review/Follow Career Center Policies and Procedures | * |
| 1.02 | Orientation to Vocational Program Classroom/Shop/Lab | * |
| 1.03 | Review Course Objectives and Standards | * |
| Unit 1.0 B | INTRODUCTION TO SAFETY | |
| 1.01 | General Orientation | * |
| 1.02 | Identify Desirable Vocational Training Safety Habits | * |
| 1.03 | Observe Classroom Safety Practices | * |
| 1.04 | Apply Fire Safety Rules and Procedures | * |
| 1.05 | Apply Electrical Safety Rules and Procedures | * |
| 1.06 | Personal Safety | * |
| Unit 1.0 C | INTRODUCTION TO LEADERSHIP/JOB COMMUNICATIONS | |
| 1.01 | Work Cooperatively with Fellow Students | * |
| 1.02 | Demonstrate Desirable Characteristics of Leadership | * |
| 1.03 | Paticipate in VICA Club Activities | * |
| 1.03 | Demonstrate Proper Use of Parliamentary Procedures | * |
| 1.03 | Communicate a Message by the Medium of a Speech | * |

* - Total Time Estimated

| | | |
|---|---|---|
| Unit 1.0 D | PREPARING FOR WORK | |
| 1.01 | Describe the Free Enterprise System and the Difference Between Labor and Management | * |
| 1.02 | Interpret Labor Laws and Regulations | * |
| 1.03 | Interpret Payroll Deductions for Taxes, etc. | * |
| 1.04 | Identify Typical Career Opportunities | * |
| 1.05 | Locate Job Opportunities | * |
| 1.06 | Prepare Resume | * |
| 1.07 | Compose a Letter of Application | * |
| 1.08 | Complete a Typical Employment Application Form | * |
| 1.09 | Interview for a Job | * |
| 1.10 | Compose Follow-up Letter | * |
| 1.11 | Identify Post-secondary Career Development Opportunities | * |
| Unit 1.0 E | INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/HABITS/ATTITUDES | |
| 1.01 | Describe Good Work Habits Important to Job Success | * |
| 1.02 | Exhibit Successful Job Performance Characteristics | * |
| 1.03 | Exhibit Desirable Work Attitudes | * |
| 1.04 | Demonstrate Respect for and Care of School Property | * |
| Unit 1.0 F | BASIC MATH SKILLS | |
| 1.01 | Basic Math - Fractions | * |
| 1.02 | Basic Math - Decimals | * |
| 1.03 | Basic Math - Volumes | * |
| 1.04 | Basic Math - Areas | * |

* - Total Time Estimated

| | | | |
|---|---|---|---|
| Unit 1.0 G | | BASIC MEASURING | |
| | 1.01 | Measuring | * |
| Unit 1.0 H | | WRITE AND READ TECHNICAL INFORMATION | |
| | 1.01 | Write Technical Information | * |
| | 1.02 | Read Technical Information | * |
| | | TOTAL HOURS | 30 |

* - Total Time Estimated

TASK LISTINGS
HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 1.0 A | INTRODUCTION/ORIENTATION |
| 1.01 | (REVIEW/FOLLOW CAREER CENTER POLICIES AND PROCEDURES) Given information on career center policies and procedures, apply these policies and procedures on a day-to-day basis. |
| 1.02 | (ORIENTATION TO VOCATIONAL PROGRAM CLASSROOM/SHOP/LAB) Given information on classroom/shop or instructor's policies and procedures, apply these policies and procedures on a daily basis, meeting the standards of the instructor 100 percent. |
| 1.03 | (REVIEW COURSE OBJECTIVES AND STANDARDS) Given an introduction to the vocational program, a review of the course objectives and minimum standards of performance; describe the course objectives, and the minimum performance expected to demonstrate competency in given objectives. |
| Unit 1.0 B | INTRODUCTION TO SAFETY |
| 1.01 | (GENERAL ORIENTATION) Given an orientation to building, shop, and fire safety; discuss, identify, or demonstrate general shop safety behavior and fire procedures. |
| 1.02 | (IDENTIFY DESIRABLE VOCATIONAL TRAINING SAFETY HABITS) Given an introduction/orientation to general safety as well as to safety in the vocational education program or on the job; identify general occupational safety habits to the satisfaction of the instructor and meet all applicable safety rules and regulations. |
| 1.03 | (OBSERVE CLASSROOM SAFETY PRATICES) Given a typical vocational classroom/shop/lab or job situations, exhibit an awareness of safety practices, safe work habits, and a postive attitude concerning job safety and accident prevention and meet standards established by the insructor. |
| 1.04 | (APPLY FIRE SAFETY RULES AND PROCEDURES) Given examples of types of fires, fire extinguishers, and possible shop situations, apply fire safety rules and procedures. Meet National and local fire safety procedures. |

1.05 (APPLY ELECTRICAL SAFETY RULES AND PROCEDURES) Given orientation to identifying electrical hazards, apply electrical safety rules and procedures. Electrical equipment with exposed wire, frayed cables, and deteriorated insulation must be reported and corrected. Proper grounding mjst be employed and maintained. Junction boxes, outlets, switches, breakers switches, and panels should be identified as to their use. Meet all applicable National and local standards and the standards of the instructor as well.

1.06 (PERSONAL SAFETY) Given instruction, identify personal safety clothing, equipment, or procedures to ensure safety in the vocational field/training, with 100 percent accuracy, demonstrate proper use of safety behavior.

## Unit 1.0 C INTRODUCTION TO LEADERSHIP/JOB COMMUNICATIONS

1.01 (WORK COOPERATIVELY WITH FELLOW STUDENTS) Given instruction and an opportunity to meet fellow students in the vocational program environment, work cooperatively with fellow students as well as with other students in related vocational learning activites. Meet the instructor's standards and cooperate to the satisfaction of fellow students as a group.

1.02 (DEMONSTRATE DESIRABLE CHARACTERISTICS OF LEADERSHIP) Given an introduction/orientation to desirable qualities of a good leader, describe characteristics typical of a good leader, discuss desirable leadership qualities, and demonstrate an ability to follow as well as take a leadership position. Performance should be satisfactory to the instructor and fellow students.

1.03 (PARTICIPATE IN VICA CLUB ACTIVITIES) Given an introduction/orientation to the Vocational Industrial Club of America (VICA), describe the general purposes of VICA, describe a typical VICA program at a vocational center, recall from memory the VICA motto, state the VICA pledge from memory, identify the symbols/symbolism in the VICA emblem, and identify what the colors of the VICA organization represents. Performance should be acceptable to the VICA Club sponsor, instructor, and VICA memebers.

1.03 (DEMONSTRATE PROPER USE OF PARLIMENTARY PROCEDURE) Given instruction, apply the principles of parliamentary procedure and describe the characteristics of a good chairman.

1.03 (COMMUNICATE A MESSAGE BY THE MEDIUM OF A SPEECH) Given instruction, list purposes of a speech, characteristics of a speech, and write and orally deliver a speech. The delivered speech should contain accurate information, be technically correct in organization and delivery, and the intended message should be communicated.

## Unit 1.0 D PREPARING FOR WORK

1.01 (DESCRIBE THE FREE ENTERPRISE SYSTEM AND THE DIFFERENCE BETWEEN LABOR AND MANAGEMENT) Given an introduction/ orientation to the free enterprise system of economics, descirbe to the satisfaction of the instructor the free enterprise system of economics as found in the United States and describe the relationship between labor and management.

1.02 (INTERPRET LABOR LAWS AND REGULATIONS) Given instruction, necessary references concerning labor laws and regulations, interpret typical labor laws and regulations. Performance must meet the instructor's standards.

1.03 (INTERPRET PAYROLL DEDUCTIONS FOR TAXES, ETC.) Given instruction and sample forms concerning income tax and other withholdings, interpret the typical forms used in income tax and other withholdings to the satisfaction of the instructor and itemize typical payroll deductions that workers encounter. Performance must be to the instructor's standards.

1.04 (IDENTIFY TYPICAL CAREER OPPORTUNITIES) Given instruction, data on the local business and industry, opportunities to study entry-level job opportunities; identify the major catagories of potential employers in the local community (and the key characteristics of each).

1.05 (LOCATE JOB OPPORTUNITIES) Given job placement information such as newspaper ads and personal contacts, list a minimum of ten specific jobs in the community. One week will be allowed to complete the task.

1.06 (PREPARE RESUME) Given examples of a suitable resume or pesonal data sheets, prepare and type (or print at a minimum) a personal resume on paper acceptable to the instructor with all errors acceptable corrected.

1.07 (COMPOSE APPLICATION LETTER) Given a newspaper ad for a job, compose a letter of application. The letter must be mailable and must include all necessary personal information.

1.08 (COMPLETE A TYPICAL EMPLOYMENT APPLICATION FORM) Given an employment application form typical of the job, complete the form with all information accurate, neatly typed or printed in, and aligned in the form blanks.

1.09 (INTERVIEW FOR A JOB) Given instruction on how to interview for a job, a job interview checklist, and a mock job interview; complete a job interview to the satisfaction of the instructor.

1.10 (COMPOSE A FOLLOW-UP LETTER) Given a case situation by the instructor or from the textbook, compose and write a follow-up letter appropriate to the job application or interview situation and in mailable form. The finished letter must meet the instructor's standards.

1.11 (IDENTIFY POST-SECONDARY CAREER DEVELOPMENT OPPORTUNITIES) Given an orientation to similar post-secondary career development programs, such as offered at Greenville Technical College, a report of skill competencies developed during secondary training, and other information as needed; identify post-secondary career development opportunities.

Unit 1.0 E INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/ HABITS/ATTITUDES

1.01 (DESCRIBE GOOD WORK HABITS IMPORTANT TO JOB SUCCESS). Given intorduction/orientation to desirable work habits, as described by potential emplyers or tradesmen, demonstrate desirable (good) work habits (based on information provided by the instructor) represent typical standards expected by business/industry (potential employers) for entry employment success.

1.02 (EXHIBIT SUCCESSFUL JOB PERFORMANCE CHARACTERISTICS) Given instruction, demonstrate job performance characteristics that are considered important to entry-level career success in the vocational field. A "Job Performance Rating Sheet" will be rated "frequently" or above.

1.03 (EXHIBIT DESIRABLE WORK ATTITUDES) Given instruction, demonstrate work attitudes that the majority of potential employers prefer in an entry level worker. Performance will be evaluated on a "Work Attitudes Score Card" and a minimum of 90 percent should be attained. Performance will be rated throughout training and should improve to 100 percent by the end of the training period.

1.04 (DEMONSTRATE RESPECT FOR AND CARE OF SCHOOL PROPERTY) Given a classroom, shop, or other instructional setting with access to furniture, equipment, tools and materials, and given proper instruction; demonstrate a respect for and care of public property (training facilities) and instructional materials to the standards established by The School District of Greenville County, the career center, and the instructor.

## Unit 1.0 F BASIC MATH SKILLS

1.01 (BASIC MATH - FRACITONS) Given a pretest or examples by the instructor, conduct the following operations with fractions:

1. Change any fraction to a decimal number, and any terminating decimal to a fraciton.
2. Arrange in order...unit and simple nonunit fractions.
3. Write equivalent fractions in higher, lower, and lowest terms.
4. Write improper fractions as whole or mixed numbers, and mixed numbers as improper fractions.
5. Multiply fractions and mixed numbers, expressing answers in simplest form.
6. Divide fracitons and mixed numbers, expressing answers in simplest form.
7. Add and subtract unlike fractions, expressing answers in simplest form.
8. Add and subtract mixed numbers with unlike fractions expressing answers in simplest form.
9. Use rational numbers to solve simple work problems.

1.02 (BASIC MATH - DECIMALS) Given a pretest or examples by the instructor, conduct the following decimal math operations:

1. Name the place value of digits in decimal numbers of up to nine digits before the decimal and six digits after the decimal.
2. Compare decimal numbers and arrange them in proper order.
3. Write the numeral for any decimal number of up to four decimal places.
4. Round decimal numbers to any designated place value up to thousandths.
5. Add and subtract decimal numbers of up to six digits.
6. Multiply decimal numbers by whole numbers or decimal numbers.
7. Divide a number by a three digit decimal number.
8. Multiply and divide decimal numbers by powers of ten, by inspection.

1.03 (BASIC MATH - VOLUMES) Given a pretest or examples by the instructor, find the volume of any rectangular prism or cube.

1.04 (BASIC MATH - AREAS) Given a pretest or examples by the instructor, find the area of the following types of figures:

a. Rectangle and square
b. Circle

Unit 1.0 G BASIC MEASURING

1.01 (MEASURING) Given proper instructions, read a rule and use other measuring tools with the precision necessary to take measurements or set them up.

Unit 1.0 H WRITE AND READ TECHNICAL INFORMATION

1.01 (WRITE TECHNICAL INFORMATION) Given instruction and an introduction to the trade program and the terminology of the trade, write technical reports/communications that convey the intended messages and that can be read intelligently by another student/tradesman. Student performance must be acceptable to the instructor.

1.02 (READ TECHNICAL INFORMATION) Given an introduction to the trade program and the terminology used in the trade, read and interpret technical literature or information concerning trade operations. Reading competencies should be demonstrated by the ability to read and interpret information from blueprints and specifications, technical instructions, and manufacturer's manuals on equipment. Student performance must be acceptable to the instructor.

# UNIT 1.0 A

# INTRODUCTION/ORIENTATION

UNIT 1.0 A INTRODUCTION/ORIENTATION

TASK 1.01 REVIEW/FOLLOW CAREER CENTER POLICIES AND PROCEDURES

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PERFORMANCE OBJECTIVE:

Given information on career center policies and procedures, apply these policies and procedures on a day-to-day basis.

PERFORMANCE ACTIONS:

1.0101 Review center policies and procedures.

1.0102 Review relevant philosophy of center and, The School District of Greenville County, and the South Carolina State Department of Education.

1.0103 Review relevant safety policies and procedures under unit concerning safety and practice desired safety behavior as outlined in relevant safety policies and procedures.

PERFORMANCE STANDARDS:

- Using information and materials supplied, review and apply career center policies and procedures daily.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Center Student Handbook.
- High School Student Handbook.
- Written Policies and Procedures of The School District of Greenville County.
- Policies and Procedures of the South Carolina State Department of Education.
- "Autorization" and "release" forms (such as safety releases).

UNIT 1.0 A INTRODUCTION/ORIENTATION

TASK 1.02 ORIENTATION TO VOCATIONAL PROGRAM CLASSROOM/SHOP/LAB

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PERFORMANCE OBJECTIVE:

Given information on classroom/shop or instructor's policies and procedures, apply these policies and procedures on a daily basis, meeting the standards of the instructor 100 percent.

PERFORMANCE ACTIONS:

1.0201 Review with instructor the shop policies and procedures.

1.0202 Apply, with 100 percent accuracy, the policies and procedures of the vocational program, shop, or instructor.

PERFORMANCE STANDARDS:

- Apply information/instruction given during orientation and throughout training period to comply with all policies and procedures of the shop (instructor) on a day-to-day basis.
- Standards of the State, School District, Career Center, and high school, and instructor apply.

SUGGESTED INSTRUCTION TIME:

RECOMMENDED:

- Vocational education (shop) policies and procedures should be written and posted or distributed to students.

UNIT 1.0 A INTRODUCTION/ORIENTATION

TASK 1.03 REVIEW COURSE OBJECTIVES AND STANDARDS

---

PERFORMANCE OBJECTIVE:

Given an introduction to the vocational program, a review of the course objectives and minimum standards of performance; describe the course objectives, and the minimum performance expected to demonstrate competency in given objectives.

(NOTE: This task may be accomplished in general at the beginning of the first year and in detail over the two year training period.)

PERFORMANCE ACTIONS:

1.0301 Review each major objective of the vocational program as outlined in this articulated, performance-based instruction objectives guide.

1.0302 Review the minimum performance standards of the objectives.

Possible Alternate Actions:

Instructor may require students to identify objectives and standards at the initiation of each new unit of instruction.

PERFORMANCE STANDARDS:

- Using information provided, explain the objectives of the course and describe the minimum performance for each objective.

SUGGESTED INSTRUCTION TIME:

RECOMMENDATION:

- Course objectives, such as the Task Listings objectives, should be written and posted or distributed to students.

# UNIT 1.0 B

# INTRODUCTION TO SAFETY

UNIT 1.0 B INTRODUCTION TO SAFETY

TASK 1.01 GENERAL ORIENTATION

---

## PERFORMANCE OBJECTIVE:

Given an orientation to building, shop, and fire safety; discuss, identify, or demonstrate general shop safety behavior and fire procedures.

## PERFORMANCE ACTIONS:

1.0101 As applicable, discuss basic safety rules applicable to the training facility.

1.0102 Identify general shop safety rules.

1.0103
- a. Review fire safety rules with the instructor.
- b. Identify fire safety equipment, exits, and procedures in the shop and building area during a fire.

## PERFORMANCE STANDARDS:

- Follow basic safety rules and established shop safety practices.
- Follows established fire safety practices and procedures.

## SUGGESTED INSTRUCTION TIME:

UNIT 1.0 B INTRODUCTION TO SAFETY

TASK 1.02 IDENTIFY DESIRABLE VOCATIONAL TRAINING SAFETY HABITS

---

PERFORMANCE OBJECTIVE:

Given an introduction/orientation to general safety as well as to safety in the vocational education program or on the job; identify general occupational safety habits to the satisfaction of the instructor and meet all applicable safety rules and regulations.

PERFORMANCE ACTIONS:

1.0201 Listen to all information provided by the instructor or others concerning safety in the career center, vocational program and in live learning activities.

1.0202 Observe safety posters.

1.0203 Observe safety warning devices for hazardous materials or work areas.

1.0204 Demonstrate correct safety practices going to and from the classroom/shop as well as in the classroom situation.

1.0205 Describe the effect of accidents on the production dollar, due to possible time loss.

1.0206 Observe learning situations or other situations for the observation of safe situations as well as violation of proper safety rules and regulations.

PERFORMANCE STANDARDS:

- To the standards of the instructor and standards applicable to the classroom or school or in the vocational field, demonstrate desirable occupational safety habits.
- "Zero" accidents.
- "Zero" safety violations.

SUGGESTED INSTRUCTION TIME:

UNIT 1.0 B INTRODUCTION TO SAFETY

TASK 1.03 OBSERVE CLASSROOM SAFETY PRACTICES

---

PERFORMANCE OBJECTIVE:

Given a typical vocational classroom/shop/lab or job situation, exhibit an awareness of safety practices, safe work habits, and a positive attitude concerning job safety and accident prevention and meet standards established by the instructor.

PERFORMANCE ACTIONS:

1.0301 Develop an awareness of vocational training/job hazards and become more safety conscious.

1.0302 Develop a serious attitude toward the daily use of safety procedures.

1.0303 Prepare for safety before entering the training work area.

1.0304 Prepare for safety at the work station.

1.0305 Prepare for safety on existing the training work area.

1.0306 Demonstrate knowledge of general safety color coding in the training/job facility and on equipment and tools.

1.0307 Practice safe procedures/habits daily.

PERFORMANCE STANDARDS:

- "Zero-level" accident record in vocational program.
- Instructor's standards based on recommended resources.
- Applicable OSHA Standards.

SUGGESTED INSTRUCTION TIME:

POSSIBLE RESOURCES:

Current vocational program safety guide publication of The School District of Greenville County.

Jacobs, Clinton O., and Howard J. Turner, Developing Shop Safety Skills, Athens, GA: American Association for Vocational Instructional Materials. (Approximately 80 pages of brief, visually clear suggestions concerning a variety of shop safety situations. Good student or resource manual.)

TASK 1.03 OBSERVE CLASSROOM SAFETY PRACTICES (Con't.)

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RECOMMENDED RESOURCES:

Safety Handbook, A Guide for Trade and Industrial Programs, Clemson University, SC: Vocational Education Media Center, 1968. (No. 13/2/70, $2.25: Accompanying 31 Transparencies, No 9/8/68, $5.75.) Available from Trades and Industries Division Supervisor, Office of Vocational Education, South Carolina State Department of Education or from the Vocational Education Media Center, Clemson University, SC.

Planning for Emergencies, Occupational Safety and Health Short Course Number Seven, Columbia, SC: SC State Board for Technical and Comprehensive Education.

Notgrass, Troy. Safety Handbook for ICT. The University of Texas at Austin: Center for Occupational Curriculum Development, Division of Continuing Education, 1978.

Hoerner, Thomas A., and Mervin D. Bettis, Power Tool Safety and Operation, St. Paul, MI: Hobar Publications, 1977.

RELATED TECHNICAL INFORMATION:

- Regulations of individual center or vocational program.
- Regulations of The School District of Greenville County.
- Codes, laws, and ordinances.
- Materials and equipment handbooks and manuals.
- OSHA Regulations.
- E.P.A. Regulations.

UNIT 1.0 B INTRODUCTION TO SAFETY

TASK 1.04 APPLY FIRE SAFETY RULES AND PROCEDURES

---

PERFORMANCE OBJECTIVE:

Given examples of types of fires, fire extinguishers, and possible shop situations, apply fire safety rules and procedures. Meet National and local fire safety procedures.

PERFORMANCE ACTIONS:

1.0401 Identify and explain application for fire extinguishers of the following types:

a. Form
b. Carbon Dioxide
c. Soda Acid
d. Pump Tank
e. Gas Cartridge
f. Dry Chemical
g. Multi-purpose Dry Chemical

1.0402 Describe procedures for operating selected fire extinguishers.

1.0403 Identify potential causes of fire in the vocational field/shop and common methods for avoiding or preventing fires.

1.0404 Inspect shop/laboratory for conformity with fire safety rules and procedures.

1.0405 Identify/explain relevant safety precautions applicable to vocational training activities.

PERFORMANCE STANDARDS:

- Apply applicable fire safety rules and procedures to the vocational program/training meeting all applicable standards, National and local, and meeting instructor's standards.

SUGGESTED INSTRUCTION TIME:

UNIT 1.0 B INTRODUCTION TO SAFETY

TASK 1.05 APPLY ELECTRICAL SAFETY RULES AND PROCEDURES

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## PERFORMANCE OBJECTIVE:

Given orientation to identifying electrical hazards, apply electrical safety rules and procedures. Electrical equipment with exposed wire, frayed cables, and deteriorated insulation must be reported and corrected. Proper grounding must be employed and maintained. Junction boxes, outlets, switches, breaker switches, and panels should be identified as to their use. Meet all applicable National and local standards and the standards of the instructor.

## PERFORMANCE ACTIONS:

1.0501 Explain the importance of labeling circuit breakers.

1.0502 Explain the importance of proper grounding of machines or equipment of electrically operated hand tools.

1.0503 Demonstrate/explain methods for using flexible extention cords, long cables, or drop lights.

1.0504 Identify electrical hazards and explain safety rules pertaining to the vocational field of training.

1.0506 Interpret safety precautions for electricity in the vocational shop.

## PERFORMANCE STANDARDS:

- Apply electrical safety rules and procedures for the vocational shop/laboratory, including field training locations, on a day-to-day basis meeting all applicable National and local safety rules and regulations as well as the standards of the instructor.

## SUGGESTED INSTRUCTION TIME:

(NOTE: Specific safety procedures and recommendations pertaining to a tool and equipment item may be included as a part of the task description concerning the tool/equipment.)

UNIT 1.0 B INTRODUCTION TO SAFETY

TASK 1.06 PERSONAL SAFETY

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PERFORMANCE OBJECTIVE:

Given instruction, identify personal safety clothing, equipment, or procedures to ensure safety in the vocational field/training, with 100 percent accuracy, demonstrate proper use or safety behavior.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 1.0601 | List and explain personal safety rules/ procedures. |
| 1.0602 | Identify appropriate protective clothing/ equipment/etc., used in the vocational field/ training. possibly form a given list, sketch, or mock-up. |

PERFORMANCE STANDARDS:

- Given a list, sketch, or mock-up, identify with 100 percent accuracy personal safety clothing, equipment, etc., used in the vocational field.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Additional personal safety training will be integrated into occupational task training.

Addendum to Safety Unit

## STUDENT'S SAFETY PLEDGE
## AND
## PARENT'S/GUARDIAN'S PERMISSION FOR OCCUPATIONAL TRAINING

______________________________, as part of vocational education training, will use/operate potentially hazardious occupational tools, machinery, equipment, and materials typical of the vocational field; provided that the student pledges to follow all safety rules and regulations of the instructor/career center/The School District of Greenville County and provided that the student's parent or guardian grants permission for occupational training by signing the release below.

TO THE STUDENT:

The vocational student will be given proper instruction, both in the use of and correct safety procedures concerning occupational tools, machinery, equipment, and materials typical to the vocational field before being allowed to use/operate them.

The student must assume responsibility for following safe practices and rules, and therefore the student is asked to subscribe to the following safety pledge.

### STUDENT'S SAFETY PLEDGE

1. "I (student) promise to follow all safety rules of the instructor/of the shop,
2. "I promise never to use a tool, machine, piece of equipment, or material of the vocational program without first having permission from the instructor.
3. "I will not ask permission to use a particular tool, machine, or piece of equipment unless I have been instructed in its use, and have made 100 percent on the safety test for that tool, machine or equipment.
4. "I will report any accident or injury to the vocational instructor immediately.
5. "I will report any potentially hazardious situation to the vocational instructor immediately."

Date __________ Student's Signature ________________________

### PARENT'S/GUARDIAN'S PERMISSION

"I hereby give my consent to allow my son/daughter to use/operate all occupational tools, machines, equipment, and materials necessary in carrying out the requirements of the vocational program of training."

Date __________ Parent's/Guardian's Signature ________________

(Parents are cordially invited to visit the shop to inspect the occupational tools, machines, and equipment and to see them in operation.)

BEST COPY AVAILABLE

# UNIT 1.0 C

## INTRODUCTION TO LEADERSHIP/ JOB COMMUNICATIONS

The following publications are recommended as references for the instructor or student for this unit:

Gooch, Bill G., Lois Carrier, and John Huck. WORK: Pathway to Independence, Alsip, IL: American Technical Publishers, Inc., 1979.

Gooch, Bill G., Lois Carrier, and John Huck. The Work Book (Student workbook accompanying above title), Alsip, IL: American Technical Publishers, Inc., 1979.

Gooch, Bill G., Lois Carrier, and John Huck. Instructor's Guide for WORK: Pathway to Independence, Alsip, IL: American Technical Publishers, Inc., 1979.

(NOTE: These references are also recommended for units 1.0 D and 1.0 E.)

## TASK 1.01 WORK COOPERATIVELY WITH FELLOW STUDENTS

---

PERFORMANCE OBJECTIVE:

Given instruction and an opportunity to meet fellow students in the vocational program environment, work cooperatively with fellow students as well as with other students in related vocational learning activities. Meet the instructor's standards and cooperate to the satisfaction of fellow students as a group.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 1.0101 | Participate in class and group learning activities. |
| 1.0102 | Encourage team work. |
| 1.0103 | Help plan student activities that promote cooperation. |

PERFORMANCE STANDARDS:

- Work cooperatively with fellow students to the standards of the instructor and to the standards expected by fellow students as a group.

SUGGESTED INSTRUCTION TIME:

UNIT 1.0 C INTRODUCTION TO LEADERSHIP

TASK 1.02 DEMONSTRATE DESIRABLE CHARACTERISTICS OF LEADERSHIP

---

## PERFORMANCE OBJECTIVE:

Given an introduction/orientation to desirable qualities of a good leader, describe characteristics typical of a good leader, dicuss desirable leadership qualities, and demonstrate an ability to follow as well as take a leadership position. Performance should be satisfactory to the instructor and fellow students.

## PERFORMANCE ACTIONS:

| | |
|---|---|
| 1.0201 | Define (process of) leadership and why it is desirable in a job situation. |
| 1.0202 | Describe (minimum of five) positive characteristics desirable in a good leader(based on instruction). |
| 1.0203 | Identify (three) basic steps to becoming a good leader. |
| 1.0204 | Identify (five) benefits from developing good leadership qualities. |
| 1.0205 | Demonstrate leadership qualities by participating as a fellow or member of a group and, if required, participating as a group leader. |

## PERFORMANCE STANDARDS:

- Participate as a contributing member of a group, such as the vocational class or VICA, and demonstrate desirable leadership qualities as outlined by the vocational program instructor.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- VICA Objectives.
- State Department of Education, District, and instructor supplied materials.

(NOTE: A student self-rating checklist or scale may be used in evaluation and evaluation may include ratings by other students as well as by the instructor.)

Addendum to Task 1.02 C

## LEADERSHIP RATING SCALE

DIRECTIONS: Check the appropriate parenthesis to indicate your impression of the leadership characteristics being rated.

| | | Not Observed | Needs Improvement | Observed |
|---|---|---|---|---|
| 1. | Exerts positive leadership. | ( ) | ( ) | ( ) |
| 2. | Thoughful of feelings of others. | ( ) | ( ) | ( ) |
| 3. | Enthusiasm is sincere and contagious. | ( ) | ( ) | ( ) |
| 4. | Perserves until job is completed. | ( ) | ( ) | ( ) |
| 5. | Cheerful disposition. | ( ) | ( ) | ( ) |
| 6. | Gets along well with team members. | ( ) | ( ) | ( ) |
| 7. | Gets along well with instructor/ supervisor. | ( ) | ( ) | ( ) |
| 8. | Reacts constructively to criticism. | ( ) | ( ) | ( ) |
| 9. | Punctual and gets job assignment done on time. | ( ) | ( ) | ( ) |
| 10. | Free from prejudice. | ( ) | ( ) | ( ) |
| 11. | Enjoys being a part of a group. | ( ) | ( ) | ( ) |
| 12. | Reliable. | ( ) | ( ) | ( ) |
| 13. | Adaptive to most situations. | ( ) | ( ) | ( ) |
| 14. | Not easily discouraged. | ( ) | ( ) | ( ) |
| 15. | Applies self to problems of job assignment. | ( ) | ( ) | ( ) |
| 16. | Admits mistakes when made. | ( ) | ( ) | ( ) |
| 17. | Tries to understand the other fellow's point of view. | ( ) | ( ) | ( ) |
| 18. | Makes decisions quickly and accurately. | ( ) | ( ) | ( ) |
| 19. | Seeks advise of others when appropriate. | ( ) | ( ) | ( ) |
| 20. | Looks for opportunities to make improvements in job or work assignments. | ( ) | ( ) | ( ) |

UNIT 1.0 C — INTRODUCTION TO LEADERSHIP

TASK 1.03 (Optional) — PARTICIPATE IN VICA CLUB ACTIVITIES*

---

PERFORMANCE OBJECTIVE:

Given an introduction/orientation to the Vocational Industrial Club of America (VICA)*, describe the general purposes of VICA, describe a typical VICA program at a vocational center, recall from memory the VICA motto, state the VICA pledge from memory, identify the symbols/symbolism in the VICA emblem, identify what the colors of the VICA organization represent. Performance should be acceptable to the VICA Club sponsor, instructor, and VICA Club members.

*Or a alternate, approved student organization.

PERFORMANCE ACTIONS:

1.0301 Join the VICA Club sponsored by the Career Center and vocational program.

1.0302 Participate actively as a member or an officer in the local VICA Club.

1.0303 Describe the purpose of VICA.

1.0304 Recall from memory the VICA motto.

1.0305 State the VICA pledge from memory.

1.0306 Name a minimum of five beliefs the VICA creed emphasizes.

PERFORMANCE STANDARDS:

- Demonstrate orally or in writing, from memory, accurate recall of the VICA motto, pledge, and at least five of the six beliefs of the VICA creed, and described the purpose of VICA to the satisfaction of the VICA sponsor or VICA Club officers and members as well as to the satisfaction of the vocational program instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- VICA publication(s).
- VICA emblem.
- VICA motto, pledge, and creed.
- Local VICA Club in Career Center.

TASK 1.03 (Con't.) (Optional) DEMONSTRATE PROPER USE OF PARLIAMENTARY PROCEDURE

PERFORMANCE OBJECTIVE:

Given instruction, apply the principles of parliamentary procedure and describe the characteristics of a good chairman.

PERFORMANCE ACTIONS:

1. Identify two basic principles upon which parliamentary procedure is based.
2. List two important characterists of a "good" chairman.
3. Define or identify types of motions.
4. Describe/identify the order of business for a meeting conducted by parliamentary procedure.
5. Describe/identify the characteristics of the kinds of motions used in conducting a typical meeting by parliamentary procedure.
6. Demonstrate ability to use parliamentary procedure correctly.

PERFORMANCE STANDARDS:

- Define parliamentary procedure and how it is used to contribute to a meeting, identify the charactistics of a good chairman, and used parliamentary procedures correctly meeting the standards of the instructor.

SUGGESTED INSTRUCTION TIME:

(NOTE: "This activity should be integrated into VICA activities and objectives.")

RELATED TECHNICAL INFORMATION:

- Robert's Rules of Order.
- VICA Club.
- Public Speaking.

TASK 1.03 (Con't.) (Optional) COMMUNICATE A MESSAGE BY THE MEDIUM OF A SPEECH

---

PERFORMANCE OBJECTIVE:

Given instruction, list purposes of a speech, characteristics of a speech, and write and orally deliver a speech. The delivered speech should contain accurate information, be technically correct in organization and delivery, and the intended message should be communicated.

PERFORMANCE ACTIONS:

1. Identify three purposes for making a speech.
2. Write an outline for a proposed speech.
3. List at least five methods/ways to make a speech effective/interesting.
4. Deliver a three to five minute speech that successfully communicates the intended message.

PERFORMANCE STANDARDS:

- Successfully communicate intended message by a speech using proper techniques and meeting instructor's (or VICA sponsor's) standards.

ALTERNATE STANDARD:

- Student is to describe verbally, task being performed, techniques used, etc., to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

(NOTE: "This activity may be integrated into VICA activities and objectives.")

RELATED TECHNICAL INFORMATION:

- VICA Club.
- Communications.

# UNIT 1.0 D

# PREPARING FOR WORK

UNIT 1.0 D PREPARING FOR WORK

TASK 1.01 DESCRIBE THE FREE ENTERPRISE SYSTEM AND THE DIFFERENCE BETWEEN LABOR AND MANAGEMENT

---

PERFORMANCE OBJECTIVE:

Given an introduction/orientation to the free enterprise system of economics, describe to the satisfaction of the instructor the free enterprise system of economics as found in the United States and describe the relationship between labor and management.

PERFORMANCE ACTIONS:

1.0101 Read assignments in trade magazines or periodicals.

1.0102 Listen to talks by representatives of labor and management.

1.0103 Discuss the Free Enterprise System as represented by business/industry in the United States.

1.0104 Discuss problems concerning employee-management-trade union transactions.

PERFORMANCE STANDARDS:

- To the satisfaction of the instructor describe the Free Enterprise System of economics as represented by business/industry in the United States.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Free Enterprise System of Economics.
- Management and Labor Relationships.

| | |
|---|---|
| UNIT 1.0 D | PREPARING FOR WORK |
| TASK 1.02 | INTERPRET LABOR LAWS AND REGULATIONS |

---

PERFORMANCE OBJECTIVE:

Given instruction, necessary references concerning labor laws and regulations, interpret typical labor laws and regulations. Performance must meet the instructor's standards.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 1.0201 | Identify and interpret the "Fair Labor Standards Act." |
| 1.0202 | State the minimum wage for a worker. |
| 1.0203 | State the typical minimum age for a worker. |
| 1.0204 | Identify how to report earned income. |
| 1.0205 | Define overtime. |
| 1.0206 | Identify local or State laws that affect the worker. |

PERFORMANCE STANDARDS:

- Interpret typical labor laws and regulations of the Federal, State, and local level that affect the worker.
- The instructor's standards must be met.

SUGGESTED INSTRUCTION TIME:

UNIT 1.0 D PREPARING FOR WORK

TASK 1.03 INTERPRET PAYROLL DEDUCTIONS FOR TAXES, ETC.

---

## PERFORMANCE OBJECTIVE:

Given instruction and sample forms concerning income tax and other withholdings, interpret the typical forms used in income tax and other withholdings to the satisfaction of the instructor and itemize typical payroll deductions that worker encounters. Performance must be to the instructor's standards.

## PERFORMANCE ACTIONS:

1.0301 Obtain a social security card (if not acquired already). [Recommended]

1.0302 Identify the purposes of social security withholdings from pay.

1.0303 Describe who is qualified for unemployment compensation.

1.0304 Describe who qualifies for workmen's compensation.

1.0305 Complete typical forms used for Federal Income Tax Withholdings.

1.0306 Interpret a typical Federal Income Tax Wage and Tax Statement form.

1.0307 Identify typical payroll deductions.

## PERFORMANCE STANDARDS:

- Given typical forms used for payroll deduction and reporting of income and other taxes, interpret payroll deductions and other statements on the forms.
- Performance must be to the instructor's standards.

## SUGGESTED INSTRUCTION TIME:

UNIT 1.0 D PREPARING FOR WORK

TASK 1.04 IDENTIFY TYPICAL CAREER OPPORTUNITIES

---

PERFORMANCE OBJECTIVE:

Given instruction, data on the local business and industry, opportunities to study entry-level job opportunities; identify the major catagories of potential employers in the local community (and the key characteristics of each).

PERFORMANCE ACTIONS:

"Performance actions may vary from career center to career center due to the potential employers served and based on the emphasis of the individual vocational program."

PERFORMANCE STANDARDS:

- Identify typical types of entry-level jobs, in the local community, and the major characteristics that distinguish them based on given instruction, local market data, and student observation.
- Meet instructor's standards.

SUGGESTED INSTRUCTION TIME:

TASK 1.05 LOCATE JOB OPPORTUNITIES

---

PERFORMANCE OBJECTIVE:

Given job placement information such as newspaper ads and personal contacts, list a minimum of ten specific jobs in the community. One week will be allowed to complete the task.

PERFORMANCE ACTIONS:

1.0501 Identify job opportunity areas as related to training, skills, and interests.

1.0502 Contact (or list) various employment opportunity sources:

a. Job placement office.
b. Want ads.
c. Employment Security.
d. Other sources such as family, friends, school officials, etc.

1.0503 Estimate competition for job opportunities (number of other persons wanting same job) and target enough job opportunities to statistically qualify for one opportunity.

PERFORMANCE STANDARDS:

- Student must list a minimum of ten specific jobs in the community as advertised in the newspaper or media or through personal contacts.
- The jobs must be available currently.

SUGGESTED INSTRUCTION TIME:

(Skill development and performance to be demonstrated over one week.)

UNIT 1.0 D PREPARING FOR WORK

TASK 1.06 (Optional) PREPARE RESUME

---

PERFORMANCE OBJECTIVE:

Given examples of suitable resume/personal data sheets, prepare and type (or print at a minimum) a personal resume on paper acceptable to the instructor with all errors acceptable corrected.

PERFORMANCE ACTIONS:

1.0601 Define the basic purpose of the resume.

1.0602 Outline the essential information a resume of personal data sheet should contain:

a. Personal data such as name, address, telephone, age, physical descriptions, marital status, etc.
b. Job objective or skills offered.
c. Training.
d. Experience.
e. Accomplishments, interests, etc.
f. References.

1.0603 Prepare a resume that is acceptable to the instructor.

PERFORMANCE STANDARDS:

- Prepare resume/personal data sheets on paper and in a form acceptable to the instructor with all errors acceptable corrected.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Job Seeking - How and Where, Columbia, SC: South Carolina State Department of Education, 1981.

TASK 1.07 COMPOSE APPLICATION LETTER

---

PERFORMANCE OBJECTIVE:

Given a newspaper ad for a job, compose a letter of application. The letter must be mailable and must include all necessary personal information.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 1.0701 | Assemble necessary information, supplies, and equipment. |
| 1.0702 | Compose a letter of application for a given business position. Include the necessary information. |
| 1.0703 | Proofread the letter, correcting all errors. |

PERFORMANCE STANDARDS:

- Compose a letter of application for a position advertised in the local newspaper and suitable for the skills and experience of the student or for the hypothetical position described by the instructor.
- Include necessary personal information and prepare the letter in mailable form.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Job Seeking - How and Where, Columbia, SC: South Carolina State Department of Education, 1981.

TASK 1.08 COMPLETE A TYPICAL EMPLOYMENT APPLICATION FORM

---

PERFORMANCE OBJECTIVE:

Given an employment application form typical of the job, complete the form with all information accurate, neatly typed or printed in, and aligned in the form blanks.

PERFORMANCE ACTIONS:

1.0801 Assemble minimum necessary information:

- a. Personal information such as name, address, and date of birth.
- b. Data related to applicant such as social security number, etc.
- c. Schooling or training information.
- d. Past employment record.
- e. References.

1.0802 Complete the application form following directions carefully with neat, aligned entries.

1.0803 Proofread the completed form for errors or incomplete blanks.

PERFORMANCE STANDARDS:

- Complete an employment application form typical of the job with all information accurate, neatly printed or typed in and aligned in the form blanks to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Job Seeking - How and Where, Columbia, SC: South Carolina State Department of Education, 1981.

TASK 1.09 INTERVIEW FOR A JOB

---

PERFORMANCE OBJECTIVE:

Given instruction on how to interview for a job, a job interview checklist, and a mock job interview; complete a job interview to the satisfaction of the instructor.

PERFORMANCE ACTIONS:

1.0901 Prepare for the interview:

a. Prepare personal appearance.
b. Prepare necessary information, references, or other material for the interview.

1.0902 Arrive at the appropriate time and identify yourself and your purpose or appointment.

1.0903 Give a good impression in meeting the interviewer.

1.0904 Exchange essential information with the interviewer to reflect your job skills, training, and experience as well as your personality. In addition, learn about the job opportunity and employer.

PERFORMANCE STANDARDS:

- Complete a mock job interview to the satisfaction of the instructor following suggested procedures.

SUGGESTED INSTRUCTION TIME:

## TASK 1.10 (Optional) COMPOSE FOLLOW-UP LETTER

---

PERFORMANCE OBJECTIVE:

Given a case situation by the instructor or from the textbook, compose and write a follow-up letter appropriate to the job application or interview situation and in mailable form. The finished letter must meet the instructor's standards.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 1.1001 | Assemble necessary information, supplies, and equipment. |
| 1.1002 | Compose a follow-up letter, in mailable form, to a given job application or interview situation. |
| 1.1003 | Proofread the letter, correcting all errors. |

PERFORMANCE STANDARDS:

- Compose and write a follow-up letter appropriate in the judgement of the instructor to a given job application or interview situation and in mailable form.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Job Seeking - How and Where, Columbia, SC: South Carolina State Department of Education, 1981.

## TASK 1.11 IDENTIFY POST-SECONDARY CAREER DEVELOPMENT OPPORTUNITIES

---

PERFORMANCE OBJECTIVE:

Given an orientation to similar post-secondary career development programs, such as offered at Greenville Technical College, a report of skill competencies developed during secondary training, and other information as needed; identify post-secondary career development opportunities.

PERFORMANCE ACTIONS:

1.1101 Identify:

a. Need for additional training at the post-secondary level.
b. Benefits from additional training.

1.1102 a. Identify post-secondary training programs available at GTC.
b. Identify how post-secondary (GTC) training differs from secondary training in related areas.

1.1103 Visit GTC program of possible interest. Talk with instructor, department head, or admissions counselor at GTC.

1.1104 Determine, with secondary and post-secondary personnel assistance, if exemption of post-secondary level training is recommended.

1.1105 Accomplish the required steps to apply or test for exemptions (if applicable).

PERFORMANCE STANDARDS:

- Identify post-secondary training opportunities, specifically at GTC, to include: Associate Degree or Diploma in areas of possible career interest.

SUGGESTED INSTRUCTION TIME:

## UNIT 1.0 E

# INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/HABITS/ATTITUDES

UNIT 1.0 E INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/ HABITS/ATTITUDES

TASK 1.01 DESCRIBE GOOD WORK HABITS IMPORTANT TO JOB SUCCESS

---

PERFORMANCE OBJECTIVE:

Given introduction/orientation to desirable work habits, as described by potential employers or tradesmen, demonstrate desirable (good) work habits (based on information provided by the instructor) that represent typical standards expected by business/industry (potential employers) for entry employment success.

PERFORMANCE ACTIONS:

1.0101 Identify specific criteria for success in typical entry level job categories.

1.0102 Participate in planning student's learning activities.

1.0103 Maintain a clean, well-organized learning situation (desk, locker, work area, shop, etc.) which is conducive to effective learning.

1.0104 Objectively receive instructor or other critique (correction, criticism, suggestions, etc.) of learning or job performance (behavior) or product or activity.

1.0105 Describe good work habits and how they are related to job success, stability, and advancement.

PERFORMANCE STANDARDS:

- Describe to the instructor's standards good work habits that are important to job success, stability, and advancement.

SUGGESTED INSTRUCTION TIME:

UNIT 1.0 E INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/HABITS/ATTITUDES

TASK 1.02 EXHIBIT SUCCESSFUL JOB PERFORMANCE CHARACTERISTICS

---

PERFORMANCE OBJECTIVE:

Given instruction, demonstrate job performance characteristics that are considered important to entry-level career success in the vocational field. A "Job Performance Rating Sheet" will be used to evaluate performance and all items must be rated "frequently" or above.

(NOTE: It is recommended in research findings that employer-recommended "job performance characteristics" and "work attitudes" be included as part of the vocational student's overall training and that demonstrated performance in these areas be included in the total evaluation of the student.)

PERFORMANCE ACTIONS:

1.0201 Review important work characteristics for the vocational field.

1.0202 Review the "Job Performance Rating Sheet" with the instructor.

1.0203 Demonstrate those work characteristics that are considered important to success in the vocational field.

PERFORMANCE STANDARDS:

- Demonstrate by personal performance the work characteristics that are considered important.
- A "Rating Sheet" will be used to evaluate performance and all items must be rated "frequently" (observed) or above.

SUGGESTED INSTRUCTION TIME: N/A Integrated during a two-year training period.

Accompanied by addendum page (Rating Sheet)

Rating sheet might include the following categories:

- Accuracy of work
- Care of working space
- Care of equipment

Rating sheet (Con't.):

- Speed
- Use of working time
- Initiative
- Attendance
- Attitude toward fellow workers
- Attitude toward teacher
- Observance of safety rules
- Use of materials
- Responsibility
- Accident report
- Personal appearance, cleanliness

# JOB PERFORMANCE RATING SHEET

Student ____________________ Job Performed ____________

Dates from ____________________ to ____________________

Place of work ______________ Supervisor ______________

DIRECTIONS: Circle the number that best fits your opinion of the student's performance using the following factors:

| | | Never | Seldom | Frequently | Usually | Always |
|---|---|---|---|---|---|---|
| 1. | Gets to work on time | 1 | 2 | 3 | 4 | 5 |
| 2. | Uses time properly | 1 | 2 | 3 | 4 | 5 |
| 3. | Shows interest in work | 1 | 2 | 3 | 4 | 5 |
| 4. | Shows dependability | 1 | 2 | 3 | 4 | 5 |
| 5. | Is ambitious | 1 | 2 | 3 | 4 | 5 |
| 6. | Is neat (work and self) | 1 | 2 | 3 | 4 | 5 |
| 7. | Works well with others | 1 | 2 | 3 | 4 | 5 |
| 8. | Follows directions | 1 | 2 | 3 | 4 | 5 |
| 9. | Works without supervision | 1 | 2 | 3 | 4 | 5 |
| 10. | Shows good manners | 1 | 2 | 3 | 4 | 5 |
| 11. | Meets people well | 1 | 2 | 3 | 4 | 5 |
| 12. | Uses knowledge on the job | 1 | 2 | 3 | 4 | 5 |
| 13. | Seeks assistance, when necessary | 1 | 2 | 3 | 4 | 5 |

Does the worker have the skills for doing satisfactory work?
Yes __ No __

List the skills or characteristics that need to be developed or improved upon:

____________________________________________
____________________________________________
____________________________________________
____________________________________________

Additional comments:

____________________________________________
____________________________________________
____________________________________________
____________________________________________
____________________________________________

Date ______________ Supervisor ____________________

UNIT 1.0 E — INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/ HABITS/ATTITUDES

## UNIT 1.03 — EXHIBIT DESIRABLE WORK ATTITUDES

---

PERFORMANCE OBJECTIVE:

Given instruction, demonstrate work attitudes that the majority of potential employers prefer in an entry level worker. Performance will be evaluated on a "Work Attitudes Score Card" and a minimum of 90 percent should be attained. Performance will be rated throughout training and should improve to 100 percent by the end of the training period.*

PERFORMANCE ACTIONS:

1.0301 Review work attitudes considered important to success in the vocational field.

1.0302 Review the "Work Attitudes Score Card."

1.0303 Demonstrate the type of work attitudes that potential employers in the local industry report as important to job success.

PERFORMANCE STANDARDS:

- Demonstrate to 90 percent acceptable rating on a "Work Attitudes Score Card" to be completed by the instructor those work attitudes considered important by local potential employers for entry-level job success.

SUGGESTED INSTRUCTION TIME: N/A Integrated during a two-year training period.

Accompanied by addendum page (Work Attitudes Score Card)

(*NOTE: It is recommended in research study findings that employer-recommended "job performance characteristics" and "work attitudes" be included as part of the vocational student's overall training and that demonstrated performance in these areas be included in the total evaluation of the student.)

Addendum to Task 1.03 E

## WORK ATTITUDES SCORE SHEET

DIRECTIONS: Score the student on the following attitudes and work behavior by circling the appropriate description either "yes" (+) or "no" (-). Indicate any comments to support the rating or recommendations.

| | Circle | | Comments/ Recommendations |
|---|---|---|---|
| | (No) | (Yes) | |
| Cooperative | - | + | |
| Courteous | - | + | |
| Loyal to program study and job team members | - | + | |
| Tackful | - | + | |
| Self Disciplined | - | + | |
| Respectful | - | + | |
| Alert | - | + | |
| Motivated | - | + | |
| Responsible | - | + | |
| Trustworthy | - | + | |
| Dependable | - | + | |
| Cheerful | - | + | |
| Polite | - | + | |
| Interest | - | + | |
| Friendly | - | + | |
| Sympathetic (sensitive) to fellow students | - | + | |
| Accepts changes | - | + | |
| Follows rules and regulations | - | + | |
| Does share of work | - | + | |
| Helps others, if needed | - | + | |
| Works regularly | - | + | |
| On time | - | + | |
| Shows pride in work | - | + | |
| Keeps promises | - | + | |
| Does not waste time | - | + | |
| Controls anger | - | + | |
| Accepts criticism | - | + | |
| Follows superior's directions | - | + | |

28 Items total TOTAL (+'s) ________

INTERPRETATION

28 = 100% = Level 4
25 = 90% = Level 3
22 = 80% = Level 2
20 = 70% = Level 1
17 = 60% = Level 0

Student: ______________________________

UNIT 1.0 E INTRODUCTION TO DESIRABLE JOB/LEARNING CHARACTERISTICS/ HABITS/ATTITUDES

TASK 1.04 DEMONSTRATE RESPECT FOR AND CARE OF SCHOOL PROPERTY

---

## PERFORMANCE OBJECTIVE:

Given a classroom, shop, or other instructional setting with access to furniture, equipment, tools and materials, and given proper instruction; demonstrate a respect for and care of public property (training facilities) and instructional materials to the standards established by The School District of Greenville County, the career center, and the instructor.

## PERFORMANCE ACTIONS:

1.0401 Listen to information provided by the instructor and read given or posted materials concerning student behavior and care of property.

1.0402 Demonstrate respect for and care of public school property including:

a. Facilities (building, classroom).
b. Furnishing (furniture).
c. Equipment and tools.
d. Instructural materials.

## PERFORMANCE STANDARDS:

- Demonstrate respect for and care of school property as represented by the classroom, shop, equipment, tools and materials used in instruction.
- Performance must be to the standards of policies of the School District, the career center, and the instructor.

(NOTE: A willful disregard or disrespect (intentional damage or destruction) of instructional facilities, equipment, or materials should be considered a most serious situation since an employer typically would require payment for intended damages and might fire the employee or bring legal charges against the employee for intentional damage to facilities, equipment, or materials.)

SUGGESTED INSTRUCTION TIME: N/A Integrated during two-year training period.

# UNIT 1.0 F

# BASIC MATH SKILLS

UNIT 1.0 F BASIC MATH SKILLS

TASK 1.01 BASIC MATH - FRACTIONS

---

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, conduct the following operations with fractions:

1. Change any fraction to a decimal number, and any terminating decimal number to a fraction.
2. Arrange in order...unit and simple nonunit fractions.
3. Write equivalent fractions in higher, lower, and lowest terms.
4. Write improper fractions as whole or mixed numbers, and mixed numbers as improper fractions.
5. Multiply fractions and mixed numbers, expressing answers in simplest form.
6. Divide fractions and mixed numbers, expressing answers in simplest form.
7. Add and subtract unlike fractions, expressing answers in simplest form.
8. Add and subtract mixed numbers with unlike fractions, expressing answers in simplest form.
9. Use rational numbers to solve simple work problems.

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult the Math Curriculum Guide for pretests, suggested exercises, and references.

(NOTE: The level of this math skill is eighth grade, General Math I.)

SUGGESTED INSTRUCTION TIME: (Actual hours of instruction will be determined by student's math skill as indicated by pretest. Remedial instruction may be at initiation of skill development if required.)

UNIT 1.0 F BASIC MATH SKILLS

TASK 1.02 BASIC MATH - DECIMALS

---

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, conduct the following decimal math operations:

1. Name the place value of digits in decimal numbers of up to nine digits before the decimal and six digits after the decimal.
2. Compare decimal numbers and arrange them in order.
3. Write the numeral for any decimal number of up to four decimal places.
4. Round decimal numbers to any designated place value up to thousandths.
5. Add and subtract decimal numbers of up to six digits.
6. Multiply decimal numbers by whole numbers or decimal numbers.
7. Divide a number by a three-digit decimal number.
8. Multiply and divide decimal numbers by powers of ten, by inspection.

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult: Curriculum Guide for High School General Mathematics, 1979, for pretests, suggested exercises, and references.

SUGGESTED INSTRUCTION TIME: (Actual hours of instruction will be determined by the student's math skill as indicated by pretest. Remedial instruction may be at initiation of skill development if required.)

(NOTE: The level of this math skill is eighth grade, General Math I.)

TASK 1.03 BASIC MATH - VOLUMES

---

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, find the volume of any rectangular prism or cube.

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics, Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult: Math Curriculum Guide for pretests, suggested exercises, and references.

SUGGESTED INSTRUCTION TIME: (Actual hours of instruction will be determined by the student's math skills as indicated by pretest. Remedial instruction may be at initiation of skill development if required.)

(NOTE: The level of this math skill is eighth grade, General Math I.)

UNIT 1.0 F BASIC MATH SKILLS

TASK 1.04 BASIC MATH - Areas

---

PERFORMANCE OBJECTIVE:

Given a pretest or examples by the instructor, find the area of the following types of figures:

a. Rectangle and square
b. Circle

PERFORMANCE ACTIONS:

Consult: Curriculum Guide for High School General Mathematics. Greenville, SC: The School District of Greenville County, 1979.

PERFORMANCE STANDARDS:

- Student should be able to complete pretest in Math Curriculum Guide with 90 percent accuracy.
- Consult the Math Curriculum Guide for pretests, suggested exercises, and references.

SUGGESTED INSTRUCTION TIME: (Actual hours of instruction will be determined by the student's math skill as indicated by pretest. Remedial instruction may be at initiation of skill development if required.)

(NOTE: The level of this math skill is eighth grade, General Math I.)

Addendum to Unit 1.0 F

# RECOMMENDED MATH SKILLS

The following math skills are recommended for success in the heating, air conditioning, refirgeration field.

1. COMMON FRACTIONS: Reduction, addition, subtraction, multiplication, division.
2. DECIMAL FRACTIONS: Conversion of decimals to common fractions and common fractions to decimals, table of decimal equivalents, conversion of dimensions, addition, subtraction, multiplication, division.
3. PERCENTAGE: Definitions, applications to problems pertaining to shop.
4. RATIO AND PROPORTION: Definitions, direct and inverse ratios, proportions, averages.
5. MENSURATION: Rectangles, square root (optional), triangles, regular plane figures, scale, circle, cylinder, volume and weight formulas.
6. PRACTICAL COMPUTATION: Accuracy, use of diagrams, mental approximation (very important), checking results.
7. GRAPHS: Types, use of graphs (very important), bar graph.
8. MEASURING INSTRUMENTS: Micrometer, caliper.
9. PRACTICAL ALGEBRA: use of letters, substitution, simple equations
10. THE ESSENTIALS FO TRIGONOMETRY: Angles, tables, right angles, area of triangles.
11. WORK AND POWER: Foot-pound, horsepower, kilowatt, electrical horsepower, efficiency of machines.
12. SPEED RATIOS OF PULLEYS: Ratios between pulleys and flywheels.
13. METRIC CONVERSION: Explanation of tables.

# UNIT 1.0 G

# BASIC MEASURING

TASK 1.01 MEASURING

---

PERFORMANCE OBJECTIVE:

Given proper instructions, read a rule and use other measuring tools with the precision necessary to take measurements or set them up.

PERFORMANCE ACTIONS:

1.0101 Define measuring terms with 80 percent accuracy.

1.0102 Accurately identify basic tools used in measuring.

1.0103 Read a rule to the nearest feet, inches, and fractions of inches down to 1/16 inch.

1.0104 Demonstrate ability to perform following measuring skills:

a. Measure objects to nearest sixteenth of an inch when given pictures of objects and a measuring instrument.
b. Draw lines and objects to specified dimensions.

PERFORMANCE STANDARDS:

- Demonstrate ability to measure to 1/16 inch and draw lines or objects to specified dimensions (1/16 inch accuracy).

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Graduations on rule: Halves, quarters, eighths, sixteenths.
- Rules: Tapes (steel or other), folding rule, straight rule, steel square.
- Metric measurement.

EXPANSION OF TASK:

- a. Estimate a measurement to 1/32 inch.
  b. Measure using the metric system.

## DEFINITIONS

| | |
|---|---|
| MEASURING | Setting of limits or bounds according to a pre-determined standard. |
| INCH | Smallest whole unit of lineal measure typically used. |
| FOOT | Unit of measure consisting of twelve equal parts called inches. |
| FRACTION | One or more equal parts of a whole. (i.e., 1/2 inch, 1/4 inch, 3/8 inch, and 5/16 inch) |
| RULE | Instrument graduated in whole units and fractions of units and used in measuring. |
| DIMENSION | Number of full units and fraction of units between two points. |

# UNIT 1.0 H

# WRITE AND READ TECHNICAL INFORMATION

The purpose of these tasks is to develop basic knowledge and skills essential to success in the trade.

Emphasis will be on effectively and efficiently sending and receiving technical messages concerning trade operations.

TASK 1.01 WRITE TECHNICAL INFORMATION

---

PERFORMANCE OBJECTIVE:

Given instruction and an introduction to the trade program and the terminology of the trade, write technical reports/communications that can be read intelligently by another student tradesman. Student performance must be acceptable to the instructor.

The written message may include notations, etc., made on working drawings, specifications, technical instructions, or descriptions of operations using the proper terminology. The message intended must be communicated to the receiver.

While correct spelling and punctuation is desirable, emphasis will be on effective and efficient communications of a technical message.

PERFORMANCE ACTIONS:

1.0101 Interpret technical terminology commonly used in the trade.

1.0102 Write technical notations, instructions, and machining descriptions that communicate the intended message to another student, to the instructor, or to a tradesman.

PERFORMANCE STANDARDS:

- Write technical information concerning trade operations, etc., that communicates the intended message.
- Instructor's standards apply.

SUGGESTED INSTRUCTION TIME: Training integrated into all units.

RELATED TECHNICAL INFORMATION:

- Technical terminology.

UNIT 1.0 H WRITE AND READ TECHNICAL INFORMATION

TASK 1.02 READ TECHNICAL INFORMATION

---

PERFORMANCE OBJECTIVE:

Given an introduction to the trade program and the terminology used in the trade, read and interpret technical literature or information concerning trade operations. Reading competency should be demonstrated by the ability to read and interpret information from blueprints and specifications, technical instructions, and manufacturer's manuals on equipment. Student performance must be accpetable to the instructor.

PERFORMANCE ACTIONS:

1.0201 Read and interpret common technical terms used in trade as identified by the instructor.

1.0202 Read and properly interpret a written set of directions or instructions.

PERFORMANCE STANDARDS:

- Read technical information concerning trade operations, correctly interpreting the common technical terms used, so that message intended to be communicated is received.
- Instructor's standards apply.

SUGGESTED INSTRUCTION TIME: Training integrated into all units.

RELATED TECHNICAL INFORMATION:

- Technical terminology.

Addendum to Unit 1.0 H

## SUGGESTED TECHNICAL TERMS

The successful air conditioning, refrigeration, and heating tradesmen should be able to accurately read, use, and write technical terms common to the industry. The below list is a suggested starting point. The instructor probably will deleat some of the below terms and may add additional terms.

ABSOLUTE
ABSORBENT
ABSORPTION
ACCELERATE
ACCUMULATOR
ALUMINA
ADIABATIC
ALTERNATING
ALTITUDE
AMBIENT

AMMETER
AMPERAGE
AMPLIFIER
ANEMOMETER
ANHYDROUS
ANNEALING
ANODE
ARMATURE
ASPIRATING
ATMOSPHERIC

ATOMIZE
ATTENUATE
AZEOTROPIC
BAROMETER
BAUDELOT
BELLOWS
BERNOULLI
BIMETAL
BOURDON
BOWDEN

BOYLE
BRAZING
BRINE
BUNKER
BUTANE
BYPASS
CADMIUM
CALCIUM
CALIBRATE
CALORIE

CALORIMETER
CAPACITANCE
CAPACITOR
CAPILLARY
CARRENE
CASCADE
CASEHARDENED
CATHODE
CELSIUS
CENTIGRADE

CENTIMETER
CENTRIFUGAL
CHEMICAL
CIRCUIT

CLUTCH
COEFFICIENT
COLLOID
COMMUTATOR
COMPOUND
COMPRESSION
CONDENSATE
CONDENSER
CONDUCTIVITY
CONDUCTOR

CONSTRICTOR
CONTAMINANT
CONVECTION
CONVERSION
COULOMB
CRANKSHAFT
CRISPER
CRITICAL
CRYOGENICS
CYLINDER

CYLINDRICAL
DECIBEL
DEGREE-DAY
DEHUMIDIFIER
DEHYDRATOR
DEICE
DENSITY
DEODORIZER
DESICCANT
DETECTOR

DIELECTRIC
DIAPHRAGM
DICHLORODIFLUOROMETHANE
DIFFERENTIAL
DIODE
DRIER
DUCT
DYNAMOMETER
EBULATOR
ECCENTRIC

ELECTROLYTIC
ELECTROMOTIVE
ELECTRON
ELECTROSTATIC
ENTHALPY
ENTROPY
ENZYME
EPOXY
EQUALIZER
EVAPORATION

EXPANSION
FAHRENHEIT
FARAD
FLUE
FLUX

FUSIBLE
GALVANIC
GAUGE
GRILLE
GROMMET
HALIDE
HERMETIC
HONE
HUMIDIFIER
HUMIDISTAT

HYDROGEN
HYDROMETER
HYDRONIC
HYGROMETER
HYGROSCOPIC
IMPELLER
INDUCTION
INFRARED
INSULATION
INTERMITTENT

ISOTHERMAL
KILOMETER
KILOWATT
LATENT
LITHARGE
LITER
MAGNETIC
MANIFOLD
MEGOHM
MERCOID

METER
METHANOL
METRIC
MICRO
MICRON
MILLI
MODULATING
MOLECULE
MULLION
NEOPRENE

NEUTRON
NOMINAL
ORIFICE
OSCILLOSCOPE
OVERLOAD
OZONE
PITOT
PLENUM
POLYPHASE
POTENTIAL

PROTON
PSYCHROMETER
PYROMETER
RADIATION

RECIPROCATING
RECTIFIER
REFRIGERANT
REPULSION
ROTARY
ROTOR
SADDLE
SATURATION
SCAVENGER
SCHRADER

SEEBECK
SENSIBLE
SENSOR
SEQUENCE
SHROUD
SILICA
SILICON
SINTERED
SLUG
SOLDERING

SOLENOID
SPECIFIC
SQUIRREL
STATOR
STELLITE
STOKER
SUBLIMATION
SUPERHEAT
SURGE
SWAGING

SYLPHON
SYNTHETIC
TEFLON
TEMPERATURE
THERM
THERMAL
THERMISTOR
THERMODYNAMICS
THERMOELECTRIC
THERMOMETER

THERMOSTAT
THROTTLING
TORQUE
TRANSDUCER
TRANSFORMER
URETHANE
VACUUM
VAPOR
VOLTAGE
VOLUMETRIC

VORTEX
WATT
WOBBLE
WOODRUFF

# UNIT 2

## FUNDAMENTALS OF ELECTRICITY

Electrical circuit diagnosis and troubleshooting probably is the simplest, but most neglected, area of the HVAC mechanic's job. Electrical components of a system must function as a complete circuit for the electro-mechanical function to work effectively and efficiently.

This unit has been organized to provide a general introduction to HVAC electricity. This unit description may exceed or may not fully represent the degree of which the HVAC instructor elects to cover electricity fundamentals in an air conditioning, refrigeration, and heating program. This unit, however, should represent an average instructional approach to the fundamentals of electricity

Typically, instructional time, in both the classroom and shop, will emphasize the application of fundamentals to practical HVAC situations.

HVAC
FUNDAMENTALS OF ELECTRICITY
SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| UNIT 2.0 | FUNDAMENTALS OF ELECTRICITY | |
| 2.01 | (OPTIONAL) Produce Voltage by Magnetism | * |
| 2.02 | (OPTIONAL) Construct an Electromagnet | * |
| 2.03 | Measure Voltage in a Simple Circuit | * |
| 2.04 | Measure Amperage in a Simple Circuit | * |
| 2.05 | Measure Resistance in a Simple Circuit | * |
| 2.06 | Test for Continuity | * |
| 2.07 | Determine Wattage | * |
| 2.08 | Read Microfarad Rating of Capacitors | * |
| 2.09 | Test Capacitors | * |
| 2.10 | Draw a Series Resistive Circuit and Calculate Circuit Values | * |
| 2.11 | Construct a Resistive Series Circuit | * |
| 2.12 | (OPTIONAL) Construct Circuit with Batteries Wired in Series | * |
| 2.13 | Draw Parallel Resistive Circuit and Calculate Circuit Values | * |
| 2.14 | Construct a Parallel Resistive Circuit | * |
| 2.15 | (OPTIONAL) Construct a Circuit with Batteries Wired in Parallel | * |
| 2.16 | Draw a Series-parallel Resistance Circuit and Calculate Circuit values | * |

* - Total Hours Estimated

| | | |
|---|---|---|
| 2.17 | Construct a Series-parallel Resistance Circuit | * |
| 2.18 | Measure Resistance of a Single-phase Compressor | * |
| 2.19 | Determine Operating Condition of a Compressor Using the Hermetic Analyzer | * |
| 2.20 | Connect a Single-phase Step-down Transformer | * |
| 2.21 | (OPTIONAL) Connect a Single-phase Step-up Transformer | * |
| 2.22 | (OPTIONAL) Connect an Auto Transformer to Provide a Variety of Output Voltages | * |
| | TOTAL HOURS | 60 |

* - Total Hours Estimated

# TASK LISTINGS
# HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| UNIT 2.0 | FUNDAMENTALS OF ELECTRICITY |
| 2.01 | (PRODUCE VOLTAGE BY MAGNETISM) Provided with a permanent magnet, a coil wire, VOM, and adequate wire for circuit connections; produce a voltage by magnetism. The movement of the coil around the magnet or movement of the magnet through the coil must produce a voltage (deflect VOM). |
| 2.02 | (CONSTRUCT AN ELECTROMAGNET) Given specifications, iron core, magnetic wire, DC power source, and the necessary tools and materials; construct an electromagnet. The magnet, when completed will show a force by attracting a metal object and holding it while the voltage is maintained. |
| 2.03 | (MEASURE VOLTAGE IN SIMPLE CIRCUIT) Provided with a functional circuit, a drawing or schematic of the circuit, a VOM, and the necessary tools or materials; measure voltage in a simple circuit. The voltage reading observed should be equivalent to those stated on the schematic (or predetermined). |
| 2.04 | (MEASURE AMPERAGE IN SIMPLE CIRCUIT) Provided with a functional DC[1] circuit, a drawing or schematic of the circuit, VOM*, and the necessary materials; measure the current in the simple circuit. The current reading(s) must agree with values on the schematic or predetermined by the instructor.<br>[1] An AC circuit may be substituted and an amprobe used as the instrument. |
| 2.05 | (MEASURE RESISTANCE IN SIMPLE CIRCUIT) Provided with a functional cirucit, a drawing or schematic of the circuit, an ohmmeter or VOM, and required materials; measure the resistance(s) in the circuit. Resistance measurements should be equal the ohm values indicated between the test points on the schematic or should equal predetermined values measured by the instructor. |
| 2.06 | (TEST FOR CONTINUITY) Provided with a VOM*, and accessories, and assortment of components such as fuses, wire, or other devices, or given a simple circuit to test; make continuity measurements. Identify component or circuit as a conductor or non-conductor.<br>*Commercial or shop made continuity tester may be substituted. |

2.07 (DETERMINE WATTAGE) Given an electrical load and a wattmeter (or voltage and current measurements with load in operation), determine wattage. Measurement/estimate must be in agreement with predetermined or measured finding of the instructor.

2.08 (READ MICROFARAD RATING OF CAPACITORS) Given an assortment of capacitors typically used in HVAC systems, a capacitor analyzer if available, and information from the instructor; determine the microfarad ratings (within 5 percent using the analyzer) of the capacitors.

2.09 (TEST CAPACITORS) Given an ohmmeter and assorted capacitors; test the capacitors to determine if each is open, shorted, or servicable.

2.10 (DRAW A SERIES RESISTIVE CIRCUIT AND CALCULATE CIRCUIT VALUES) Given a source voltage, values for three resistances, and necessary materials; without aid of references, draw a series resistive circuit and calculate circuit values. Calculate and note on the drawing, the voltage drop across R1, R2, and R3, and the total current. Calculations must be 100 percent correct. The drawing must be correct using the proper symbols, etc.

2.11 (CONSTRUCT A RESISTIVE SERIES CIRCUIT) Given a drawing of a series resistive circuit, power source, required components, wire conductor, VOM, and necessary tools and materials; construct the series circuit. Connections must be mechanically and electrically secure, the circuit must agree with the diagram or schematic, the circuit must be operational, and measurements of resistance, voltage, and current must agree with calculated values of the circuit.

2.12 (CONSTRUCT CIRCUIT WITH BATTERIES WIRED IN SERIES) Given a diagram or schematic, several batteries, a VOM, wire conductors, and the necessary tools and materials; construct a circuit with the four batteries in series. All connections must be mechanically and electrically secure to the instructor's satisfaction and the circuit should produce a combined voltage of the batteries.

2.13 (DRAW PARALLEL RESISTIVE CIRCUIT AND CALCULATE CIRCUIT VALUES) Given a source voltage and total current for a circuit; information that the current through R1 will be 1/2 of the current through R2 which is 1/2 the current through R3; and provide the required tools and materials; draw a parallel resistive circuit and calculate circuit values. Calculate and note on the drawing, the values of R1, R2, and R3. The drawing must include the proper symbols, be neatly organized according to instructions given, and be acceptable to the instructor.

2.14 (CONSTRUCT A PARALLEL RESISTIVE CIRCUIT) Provided with a drawing/schematic of a parallel resistive circuit, required components, wire conductors, power source, VOM, and necessary tools and materials; construct the required parallel resistive circuit. Connections should be mechanically and electrically secure, the circuit should operate as intended, and mesurements of voltage, current, and resistance should be equivalent to the calculated values of the circuit. The product must be acceptable to the instructor.

2.15 (CONSTRUCT A CIRCUIT WITH BATTERIES WIRED IN PARALLEL) Given a diagram/schematic, batteries of the same voltage, wire conductors, a VOM, and necessary tools and materials; construct a circuit with batteries wired in parallel. Connections should be mechanically and electrically secure and the circuit should produce the desried voltage.

2.16 (DRAW A SERIES-PARALLEL RESISTANCE CIRCUIT AND CALCULATE CIRCUIT VALUES) Provided with a source voltage, the individual values of three resistors in the circuit, and the required materials; draw a series-parallel circuit and calculate the circuit values. Calculate and note on the drawing the values for the parallel and series branch circuits. Calculations for circuit values must be 100 percent accurate according to given voltage and resistance values. The series-parallel circuit drawing must be accurate, use the proper symbols, and be acceptable to the instructor.

2.17 (CONSTRUCT A SERIES-PARALLEL RESISTANCE CIRCUIT) Given a drawing/schematic of a series-parallel resistance circuit, values for circuit resistances, the circuit voltage, components, wire conductors, VOM, and other required materials and tools; construct a series-parallel resistance circuit. All connections will be mechanically and electrically secure, the circuit must operate as intended, and the voltage and current measurements must be equivalent to the calculated values of the circuit.

2.18 (MEASURE RESISTANCE OF A SINGLE-PHASE COMPRESSOR) Provided with an ohmmeter (VOM) and a functional single-phase compressor; measure the resistance of the windings of the compressor. The resistnace should be within a predetermined value (given by the instructor or indicated on manufacturer's data plate).

2.19 (DETERMINE OPERATING CONDITION OF A COMPRESSOR USING THE HERMETIC ANALYZER---OR equivalent instrument--). Given a single-phase compressor and a hermetic analyzer, check for ground, shorts, and continuity in the compressor. Determine the operating condition of the compressor.

2.20 (CONNECT A SINGLE-PHASE STEP-DOWN TRANSFORMER) Provided with a wiring diagram, a single-phase transformer, a power source, a VOM, and the necessary wire conductors, connectors, and tools; connect a single-phase step-sown transformer in a circuit. The transformer must be wired properly to the power source and to the remaining circuit with mechanically and electrically secure circuits.

The transformer provided should be suitable for the circuit demands.

2.21 (CONNECT A SINGLE-PHASE STEP-UP TRANSFORMER) Provided with a wiring diagram, a single-phase step-up transformer, power source, wire conductors, VOM, and necessary materials and tools; connect a single-phase step-up transformer. The transformer must be properly wired to the power source, connections should be mechanically and electrically secure, and the transformer output must provide the desired voltage and current according to the transformer rating.

2.22 (CONNECT AN AUTO TRANSFORMER TO PROVIDE A VARIETY OF OUTPUT VOLTAGES) Given a wiring diagram/schematic, an auto transformer or equivalent method of varying an output voltage, a power source, wire conductors, VOM, and required materials and tools; connect the auto transformer to provide one or more voltage less than the line voltage. The auto transformer or substitute must be wired properly to the power source, connections must be mechanically and electrically secure, and required voltages must be obtained and measured.

## SAFETY STANDARDS
## ELECTRICITY

Before changing electrical connections, remove the fuse or throw the circuit breaker or switch controlling the circuit.

Cartridge fuses should be removed with an insulted tonglike fuse puller.

Where appropriate, attach a "DANGER" tag at the electrical disconnect switch to indicate that someone is working on the circuit and the switch should not be thrown. If there is a possibility that a disconnect switch might be thrown from "off" to "on" while the circuit is under repair/service, lock the switch "open" while work is underway.

## ELECTRIC SHOCK

This information is from the article, "Electrical Shock," by Bill Welsh, in the Magazine CQ, April 1983, pages 112-114.

### 1. HOW DANGEROUS IS ELECTRICAL SHOCK TO THE ELECTRICIAN?

Electric shock dangers are well documented by the military services, the American Red Cross, and the U.S. Public Health Service.

FACT: "Most of the people who are killed by electric shock are knowledgable in electrical theory!"

CONCLUSION: "Familiarity can cause carelessness!"

### 2. HOW DOES THE BODY REACT TO THE FLOW OF ELECTRIC CURRENT?

When a person comes into contact with an electrical source (a voltage) an electric current flows.

An electric current flowing through the person can cause injury or death.

The amount of electric current that flows through a person's body when they contact an electrical source (voltage) depends upon the resistance between the contact points.

The resistance of a person's body coming into contact with an electrical source (voltage) is determined by the several factors:

a. The closer the contacts, the lower the resistance!

   For example, the resistance between two fingers on the same hand generally will be lower than between the hand and foot.

b. Damp or wet skin has a lower resistance than dry skin. Older, callused skin has a higher resistance, etc.

Typically, a person's skin resistance is about 1,000 ohms (measure of resistance) for moist, uncallused skin to about 50,000 ohms for dry, callused skin.

The human body represents "about 100 ohms of resistance from ear to ear and around 500 ohms from hand to foot, ignoring skin contact resistance."

The human body, therefore, should be considered a reasonably good conductor of electrical current, especially if sweating is present!

### 3. HOW MUCH ELECTRICAL CURRENT IS NECESSARY FOR SHOCK?

Basically, a current of around "10 milliampers* is enough to cause pain and a 100 milliamper current can cause death."

*100 milliampers = .1 amp (The typical electrical wall outlet /receptical/ generally provides at least 15 amps.)

The typical wall outlet or appliance connected to 120 volts therefore contains enough electrical voltage/current to cause death.

### 4. WHAT IS THE EFFECT OF ELECTRICAL CURRENT FLOWING THROUGH THE BODY?

| | |
|---|---|
| 2-8 milliampers (ma) | "Noticable to mild sensation of electrical shock" |
| 10 ma or more | "May cause painful shock" |
| 20 ma | "Breathing may become difficult" |
| 75 ma | Breathing "can cease completely" |

| | |
|---|---|
| 100 ma | "Heart goes into ventricular fibrillation (uncontrolled contractions of heart's ventricles)" |
| 200 ma | "Muscular contractions of the heart are severe and the heart is stopped (clamped during the shock)."<br>NOTE: "This clamping action stops the heart from going into ventricular fibrillation." This is important because it increases the person's chance of being saved.<br>Typically, a person in this condition of electric shock may be revived with artificial respiration. |
| Above 200 ma | "Causes severe burns at body contact points." May cause unconsciousness. |

5. NOTE: LOW VOLTAGE/CURRENT SHOCKS CAN BE EXTREMELY DANGEROUS

Look at the above chart (Effects of electrical current flowing through body). Note that high-current (200 ma) shock victims often can be resuscitated.

It is typical to think that a person is more likely to be killed by a high voltage/current than by a low voltage/current. "THIS IS NOT TRUE!"

It is true that the severity of the shock increases as the current increases and that current is proportional to the value of the voltage contacted.

However, at electric currents of around 200 milliampers and above, the heart suffers a clamping action that actually may protect the person.

A person is more likely to be killed from an electric current in the 100 to 200 ma range.

"Voltages as low as 24 volts" (a common voltage found in control circuits) have resulted in deaths. Therefore, the 120 volt electrical source at outlets should be considered lethal. "Almost any electrical device can produce a fatal shock if certain conditions exist."

6. HOW YOU SHOULD AID AN ELECTRICAL SHOCK VICTIM

If you witness an electrical shock accident, remember, you will not know the amount of current that is flowing through the victim's body and you will not know the victim's exact condition.

RULE 1: DO NOT ENDANGER YOURSELF!

Step 1. If possible, quickly remove the electrical source. (Pull the power plug, break the circuit at the fuse box, pull/push the victim free with a non-conducting item.)

IMPORTANT - Free the victim from the electrical source as fast as possible: A person's resistance path decreases as the current flow continues making it possible for lethal currents of 100-200 milliampers to develop when the original current was not in the fatal range. Speed is essential in rescuing the person.

Step 2. If the victim is unconscious and has stopped breathing, begin artificial respiration. NOTE: While it may take only a few minutes to revive a victim of electric shock, it has been known to take as much as 8 hours of artificial respiration to save a victim.

An electric shock victim may have no pulse and may exhibit "a condition similar to rigor mortis." Continue to apply artificial respiration until the victim recovers or until a medical specialist decides that the victim is dead.

Remember: "A victim of high-voltage/current electrical shock respond faster to artificial respiration than a victim of low-voltage/current electrical shock."

7. PRECAUTIONS YOU SHOULD TAKE TO AVOID ELECTRIC SHOCK

   a. Be careful! Remember, even low-voltage/current may be lethal.

   b. Work with a partner (not alone).

   c. Don't become complacent.

   d. Don't work with live power when you are tired.

   e. Learn to take measurements so that you do not accidently make contacts that might result in shock.

   f. Think over each move/action before working with equipment/machinery with live power.

   g. Move slowly when working with live power.

   h. Do not lunge after falling tools or equipment when working with live power.

   i. When tilting equipment on its side, etc., brace it.

   j. Abide by the National Electric Code.

   k. Follow all shop safety rules, regulations, and procedures.

REMEMBER, WITH ELECTRIC SHOCK, THERE MAY BE NO SECOND CHANCE!

TASK 2.01 (Optional) PRODUCE VOLTAGE BY MAGNETISM

---

PERFORMANCE OBJECTIVE:

Provided with a permanent magnet, a coil wire, VOM, and adequate wire for circuit connections; produce a voltage by magnetism. The movement of the coil around the magnet or movement of the magnet through the coil must produce a voltage (deflect VOM).

PERFORMANCE ACTIONS:

2.0101 Connect a generator to a VOM or equivalent (galvanometer).

2.0102 Rotate the armature.

2.0103 Observe the presence of voltage (current flow).

PERFORMANCE STANDARDS:

- Produce a voltage by a wire moving through a magnetic field, observing that voltage on a suitable device such as a galvanometer or VOM, etc.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain principles of magnetism.
- Explain characteristics of lines of force (flux).
- Discuss methods of producing voltage by means of magnetism.
- Define Alternating Current (AC).
- Explain wire rule.
- Explain coil rule.
- Explain magnetic generator principles.
- Explain safety considerations.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.02 (Optional) CONSTRUCT AN ELECTROMAGNET

---

PERFORMANCE OBJECTIVE:

Given specifications, iron core, magnetic wire, DC power source, and the necessary tools and materials; construct an electromagnet. The magnet, when completed, will show a force by attracting a metal object and holding it while the voltage is maintained.

PERFORMANCE ACTIONS:

2.0201 Assemble materials.

2.0202 Wind magnetic wire around an iron core according to directions given by the instructor. (ALTERNATE: Select a relay coil, test if for continuity with the VOM, and wire it in the required electromechanical circuit /i.e., as a relay/.)

2.0203 Assemble the required demonstration unit according to given directions.

2.0204 Apply required electricity.

2.0205 Observe electromagnetic force that attracts and holds a metal object in while voltage is applied.

PERFORMANCE STANDARDS:

- Construct an electromagnet that will attract and hold a metal object while voltage is applied.
- Recommend: Use of relay parts to demonstrate the electromagnet.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain conductor flux.
- Explain flux direction (wire rule).
- Explain flux density.
- Explain coil rule.
- Explain magnetic strength.
- Identify safety considerations.

EXPANSION OF INSTRUCTION:

- Design of relays.
- Adjustment of relays.
- Troubleshooting relays: Electrically
- Types of relays found in HVAC systems.

## TASK 2.03 MEASURE VOLTAGE IN SIMPLE CIRCUIT

---

PERFORMANCE OBJECTIVE:

Provided with a functional circuit, a drawing or schematic of the circuit, a VOM*, and the necessary tools or materials; measure voltage in a simple circuit. The voltage reading observed should be equivalent to those stated on the schematic (or predetermined).

*VOM consist of a working, calibrated VOM with proper scale(s) for measurements and accompanying test probes/leads.

PERFORMANCE ACTIONS: (This task may be accomplished as part of practical shop work.)

(NOTE: This task may follow or may be conducted jointly with the task concerning the use of the VOM. See unit on Measuring Instruments.)

2.0301 Assemble schematic/diagram/drawing of circuit, VOM and other materials necessary.

2.0302 Following given directions, measure voltage at required points in the circuit.

2.0303 Note voltage readings.

2.0304 Compare readings with voltages referenced on the schematic, etc., or predetermined readings taken by the instructor, etc.

2.0305 Note any significant differences in actual readings from given voltages.

PEFORMANCE STANDARDS:

- Measure voltage in a simple circuit noting any differences in voltages measured from voltages indicated in given information or predetermined by the instructor.
- Determine why any major differences were read.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Define volt.
- Explain what voltmeter measures.

RELATED TECHNICAL INFORMATION (Con't.):

- Describe/demonstrate use of VOM: function switch, scale reading.
- Explain different units of measurement:
    - microvolt
    - millivolt
    - volt
    - kilovolt
- Explain/demonstrate procedure/technique of measuring voltages.
- Identify safety considerations.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.04 MEASURE AMPERAGE IN A SIMPLE CIRCUIT

---

PERFORMANCE OBJECTIVE:

Provided with a functional DC* circuit, a drawing or schematic of the circuit, VOM*, and the necessary materials; measure the current in the simple circuit. The current reading(s) must agree with values on the schematic or predetermined by the instructor.

*An AC circuit may be substituted and an amprobe used as the instrument.

PERFORMANCE ACTIONS: (This task may be accomplished as part of practical shop work)

(NOTE: See unit of Measuring Instruments.)

2.0401 Assemble schematic/diagram/drawing of circuit, test instrument, and other required materials.

2.0402 Following given directions, measure current at required points in the circuit.

2.0403 Note current readings.

2.0404 Compare current readings with data from given information including component (compressor, motor, etc.) data plates, if applicable.

2.0405 Note any significant differences in actual readings compared to predetermine readings or given information concerning currents in the circuit.

PERFORMANCE STANDARDS:

- Measure amperage in a given circuit, as required, using given information and measuring instrument.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION;

- Define ampere, miliampere.
- Identify and read proper scales of VOM.
- Describe/demonstrate function switch selection on VOM.
- Explain use of shunt on VOM/ammeter.
- Describe/demonstrate proper procedures/technique for measuring current.
- Identify safety considerations.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.05 MEASURE RESISTANCE IN SIMPLE CIRCUIT

---

PERFORMANCE OBJECTIVE:

Provided with a functional circuit, a drawing or schematic of the circuit, an ohmmeter or VOM, and required materials; measure the resistance(s) in the circuit. Resistance measurements should equal the ohm values indicated between the test points on the schematic or should equal predetermined values measured by the instructor.

PERFORMANCE ACTIONS: (This task may be accomplished as part of practical shop work)

(NOTE: See unit on Measuring Instruments.)

2.0501 Assemble given information, circuit, and test instrument.

2.0502 Set up circuit and instrument for measuring resistances. (i.e., remove power from circuit, etc.)

2.0503 Make resistance measurements as directed.

2.0504 Compare resistance measurements with data from given information (i.e., resistance values given on schematic or diagram, values indicated by resistor color codes, resistance values of typical motors and HVAC components, etc.).

2.0505 Note any significant differences between measured resistances and resistances measures given or predetermined.

PERFORMANCE STANDARDS:

- Make resistance measurements in a given circuit, using proper procedures, and noting any significant differences in measures taken and given information.
- If significant differences are noted, identify the cause.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Define ohm, resistance.
- Explain characteristics of a material that is:
    - a conductor
    - an insulator
    - resitive (e.g., resistor, motor, etc.)

TASK 2.05 MEASURE RESISTANCE IN SIMPLE CIRCUIT (Con't.)

---

RELATED TECHNICAL INFORMATION:

- Identify symbol for fixed and variable resistors.
- Describe composition of several different kinds/types of resistors.
- Identify/use the resistor color code.
- Explain why components being measured must be isolated.
- Explain why readings should be taken from center scale of meter.
- Describe how to set up VOM for resistance measurements (use of multiplier ranges, ohms scale, zero adjustment of ohms scale).
- Describe/demonstrate proper procedures/techniques for making resistance measurements.
- Identify safety consideration.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.06 TEST FOR CONTINUITY

---

PERFORMANCE OBJECTIVE:

Provided with a VOM* and accessories, an assortment of components such as fuses, wire, or other devices or given a simple circuit to test; make continuity measurements. Identify component or circuit as a conductor or non-conductor.

*Commercial or shop made continuity tester may be substituted.

PERFORMANCE ACTIONS: (This task may be accomplished as part of practical shop work)

(NOTE: See unit on Measuring Instruments.)

2.0601 Assemble test instrument, given data, and circuit.

2.0602 Make continuity measurements according as required.

2.0603 Note any open, closed or grounded circuits or components where continuity conflicts with given data (schematics, diagrams, etc.).

2.0604 Identify cause of any continuity readings that are not normal.

PERFORMANCE STANDARDS:

- Test a given circuit for continuity according to given schematics, diagrams, etc., and note situations where readings are different from what is normal.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION;

- Identify component symbols.
- Describe how to set VOM up for continuity testing.
- Explain/demonstrate procedures/techniques of continuity testing.
- Identify components/circuits which may be readily tested by continuity scale.
- Identify safety considerations.

## TASK 2.07 DETERMINE WATTAGE

PERFORMANCE OBJECTIVE:

Given an electrical load and a wattmeter (or voltage and current measurements with load in operation), determine wattage. Measurement/estimate must be in agreement with predetermined or measured finding of the instructor.

PERFORMANCE ACTIONS: (This task may be accomplished as part of practical shop work)

(NOTE: See unit on Measuring Instruments.)

2.0701 Assemble unit to be measured, measuring instrument(s), and necessary materials.

2.0702 Take required measurements: Wattage directly or voltage and amperage.

a. Read watts consumed by unit.
b. If using voltage and current, calculate watt consumed by unit.

2.0703 Compare measured wattage with information given on manufacturer's data plate or references available.

2.0704 Note if unit is operating normally.

PERFORMANCE STANDARDS:

- Determine the wattage of a given electrical load.
- A wattmeter may be used or wattage may be calculated from measured voltage and amperage.
- Measurements must agree with predetermined measurements or data plate.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Define watt.
- Explain different units of measurements.
- Explain power formula.
- Describe the proper use of a wattmeter.
- Identify safety considerations.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.08 READ MICROFARAD RATING OF CAPACITORS

---

PERFORMANCE OBJECTIVE:

Given an assortment of capacitors typically used in HVAC systems, a capacitor analyzer if available, and information from the instructor; determine the microfarad ratings (within 5 percent using the analyzer) of the capacitors.

PERFORMANCE ACTIONS: (This task may be accomplished as part of shop work.)

(NOTE: See unit on Measuring Instruments also [Capacitor Analyzer and use of VOM]).

2.0801 Identify different types of capacitors:

a. List three things which may identify a starting capacitor:
   (1) See expansion task on next page*.
   (2) See expansion task on next page.
   (3) See expansion task on next page.
b. List three things which may identify a run capacitor.

2.0802 Determine capacitor microfarad rating to the standards of the instructor.

PERFORMANCE STANDARDS:

- Determine microfarad rating of capacitors to the standards of the instructor using the recommended methods.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Draw/identify symbol for a capacitor.
- Explain proper use of capacitor analyzer.
- Identify different types of capacitors and where each type typically is used.
- State units of measurement for capacitors.
- Describe how to compute total capacitance in:
  a. series: 2 capacitors; more than 2 capacitors
  b. parallel: 2 capacitors or more
- Identify safety considerations.

*EXPANSION OF TASK: "Determine replacement capacitor"

- Start capacitors are typically above 50 MFD.
- Run capacitors are typically below 50 MFD.
- Start capacitors have a tolerance of +/- 20 percent.
- Run capacitors have a +/- 10 percent tolerance (a 20 MFD capacitor may be replaced with an 18-22 MFD capacitor).
- Replacement capacitors must have the same or a higher voltage rating than the capacitor replaced.
- Starting capacitors are of elctrolyte type.
- The starting capacitors is in the motor circuit only during starting conditions.
- The run capacitor is in the circuit all the time the compressor is operating.
- Start capacitors typically are bakelite or paper/plastic covered.
- Run capactiors typically are aluminum (cans) which may be paper covered.

## TASK 2.09 TEST CAPACITORS

---

### PERFORMANCE OBJECTIVE:

Given an ohmmeter and assorted capacitors; test the capacitors to determine if each is open, shorted, or servicable.

### PERFORMANCE ACTIONS:

2.0901 Review directions for use of VOM (Ohmmeter) to test capacitor.

2.0902 Identify that capacitors are either:

a. Servicable
b. Short
c. Open

2.0903 Check status of capacitors by properly using the VOM, adjusted to the recommended Ohm's Scale.

2.0904 Determine the microfarads of the capacitor: (ORIENTATION ONLY)

a. Read voltage rating of capacitor.
b. Set up for determining MFD from voltage and amperage measurements, using a power source equal to or less than the rating of the capacitor.
c. Take voltmeter measurement.
d. Take ammeter measruement.
e. Apply formula: $\text{MFD's} = \frac{2560 \times \text{Amperes}}{\text{Volts}}$
f. Check MFD determined by measurements with MFD indicated on capacitor to estimate deterioration.

### PERFORMANCE STANDARDS:

- Determine if a given capacitor is open, short, or servicable using a VOM and Amprobe.
- Findings must agree with predetermined findings or be acceptable to the instructor.

### SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe procedure for checking capacitors with the ohmmeter or VOM (typically using R x 1 scale).
- Describe how to safely handle capacitors (e.g., discharging prior to testing).
- Explain:

$$\text{MFD} = 2650 \times \frac{I}{E}$$

$$\text{Capacitance} = \frac{\text{amps} \times 2650}{\text{voltage}} = \text{MFD } (\mu\text{F})$$

- Describe how capacitor reactance can cause out of phase condition (where voltage lags behind current).
- Identify 3 things that can go wrong with a capacitor: open or short (deteriorated omitted).
- Identify typical causes of capacitor failure:
    - Stuck or fused switch or relay contacts.
    - Worn or frozen motor bearings.
    - Excessive load on motor due to slow starting.
    - Incorrect capacitor ratings.
    - Low line voltage.
    - Shorted capacitor case.
- Electrolytics are designed for about 50,000 starts.
    - Electrolytics failure typically has no external sign and 85 percent of failures are open capacitors.
- Paper oil running capacitors are good for about 15 years.
    - Paper oil running capacitors typically fail by opening and often show a bulge indicating failure.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.10 DRAW A SERIES RESISTIVE CIRCUIT AND CALCULATE CIRCUIT VALUES

---

PERFORMANCE OBJECTIVE:

Given a source voltage, values for three resistances, and necessary materials; without aid of references, draw a series resistive circuit and calculate circuit values. Calculate and note on the drawing, the voltage drop across R1, R2, and R3, and the total current. Calculations must be 100 percent correct. The drawing must be correct using the proper symbols, etc.

PERFORMANCE ACTIONS: (Resistances may be represented by resistors, light bulbs, motor,or other devices.)

2.1001 Identify given resistors (R1,R2, and R3) values and a given source voltage value.

(Sample: 20 ohms each, 120 volt source = 60 ohms total with a current of 2 amps per resistance.)

2.1002 Draw series circuit with three resistances* across the power source. (*resistors, light bulbs, motors, etc.)

2.1003 Apply rule that resistors add in series. Apply Ohm's Law.

2.1004 Calculate circuit values including total resistance, voltage drop across each resistance, and current flow through each resistor.

2.1005 Check calculations with measuring instruments, if required by instructor: Otherwise, check claculations with instructor's findings.

PERFORMANCE STANDARDS:

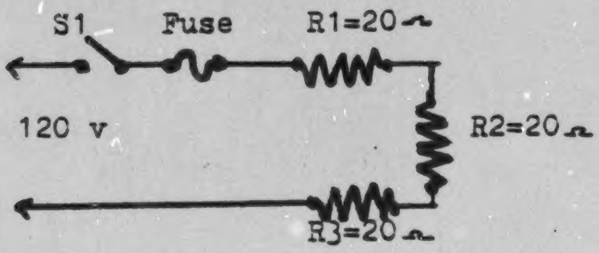
- Draw a series resistive circuit and calculate circuit values showing the voltage drop across R1, R2, and R3, and the total current.
- Calculations must be 100 percent accurate and the drawing must be correct with the proper symbols used.

SUGGESTED INSTRUCTION TIME:

---

RELATED TECHNICAL INFORMATION:

- Explain Ohm's Law (Ohm's Law formular).
- Kirchoff's Law for service circuits.
- Describe characterisitcs of series resistive circuit.
- Explain voltage drop.
- Practice electrical circuit drawing skills.
- See sample drawing below:



$I = \frac{E}{R} = \frac{120v}{60\Omega} = 2$ Amps.

$20\Omega \times 2A = 40v$
$20 \times 2 = 40$
$\underline{20 \times 2 = 40}$
$60\Omega \times 2 = 120v$

Rtot= R1+R2+R3
Rt =20+20+20
R total = $60\Omega$

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.11 CONSTRUCT A RESISTIVE SERIES CIRCUIT

---

PERFORMANCE OBJECTIVE:

Given a drawing of a series resistive circuit, power source, required components, wire conductor, VOM, and necessary tools and materials; construct the series circuit. Connections must be mechanically and electrically secure, the circuit must agree with the diagram/schematic, the circuit must be operational, and measurements of resistance, voltage, and current must agree with calculated values of the circuit.

PERFORMANCE ACTIONS:

2.1101 After drawing and calculating series resistive circuits, obtain from the instructor a drawing or schematic of a series resistive circuit to construct.

2.1102 Construct one or more series circuits, as required, following recommended techniques.

2.1103 Use ohmmeter to determine circuit resistances.

2.1104 Compare measured resistances with calculations.

2.1105 Measure voltage drop across resistors.

2.1106 As required by the instructor, use Ohm's Law and Power Law to calculate resistance, resistor wattage, and voltage drop for given practical HVAC problems.

PERFORMANCE STANDARDS:

- Following a given diagram/schematic construct an operational series circuit using three resistors.
- Mechanical and electrical connections must be secure.
- Measurements of resistance, voltage, and current must agree with calculated values of the circuit.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify components indicated on drawing/schematic.
- Describe proper VOM connections to circuit for desired measurements (voltage, resistance, current).
- Explain methods of making mechanically and electrically secure connections.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.12 (Optional) CONSTRUCT CIRCUIT WITH BATTERIES WIRED IN SERIES

---

PERFORMANCE OBJECTIVE:

Given a diagram or schematic, several batteries, a VOM, wire conductors, and the necessary tools and materials; construct a circuit with the four batteries in series. All connections must be mechanically and electrically secure to the instructor's satisfaction and the circuit should produce a combined voltage of the batteries.

PERFORMANCE ACTIONS:

2.1201 Wire the required number of batteries in series following recommended procedures.

2.1202 Calculate the voltage anticipated.

2.1203 Set up the VOM and measure the total voltage produced by the battery circuit.

PERFORMANCE STANDARDS:

- Construct a circuit with batteries wired in series so that a total voltage equals the combined voltage of the batteries.
- The circuit must be constructed to represent the given diagram/schematic and must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify symbol for a dry cell/battery.
- Review basic information concerning batteries.
- Identify safety considerations.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.13 DRAW PARALLEL RESITIVE CIRCUIT AND CALCULATE CIRCUIT VALUES

---

PERFORMANCE OBJECTIVE:

Given a source voltage and total current for a circuit; information that the current through R1 will be 1/2 of the current through R2 which is 1/2 the current of R3; and provided the required tools and materials; draw a parallel resitive circuit and calculate the circuit values. Calculate and note on the drawing, the values of R1, R2, and R3. The drawing must include the proper symblos, be neatly organized according to instructions given, and be acceptable to the instructor.

PERFORMANCE ACTIONS:

2.1301 a. State that resistances do not add as they do in a series circuit.
b. State rule for parallel resistors that are:
(1) equal
(2) not equal

2.1302 Draw several parallel circuits from information given by the instructor.

2.1303 Use Ohm's Law and Kirchoff's Law to determine circuit values.

2.1304 Check circuit values with VOM and ammeter.

PERFORMANCE STANDARDS:

- Draw a parallel resistance circuit and calculate the circuit values based on a given voltage and current for the circuit; information that the current through R1 is 1/2 of the current through R2 which is 1/2 the current through R3.
- The drawing must represent a parallel circuit, include proper symbols, and be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

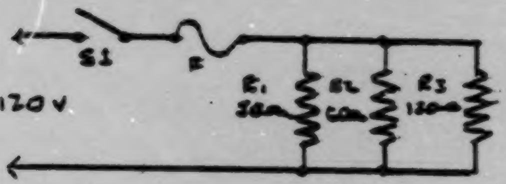
RELATED TECHNICAL INFORMATION:

- Kirchoff's Law for parallel circuits.
- Describe characteristics of a parallel circuit.
- Explain how to solve for R-total in parallel.

---

RELATED TECHNICAL INFORMATION (Con't.):

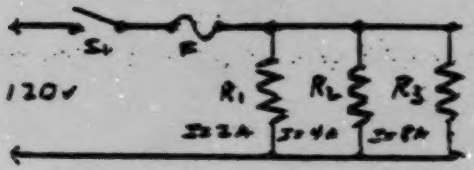
- Describe/demonstrate how to draw/wire parallel circuits. Refer to sample circuits below:


S1
F
120 V
R1 30Ω
R2 60Ω
R3 120Ω

$$\frac{1}{R_T} = \frac{1}{30} + \frac{1}{60} + \frac{1}{120} = \frac{4+2+1}{120} = \frac{7}{120}$$

$$R_T = \frac{120}{7} = 17.14\,\Omega$$

$$I = \frac{E}{R} = \frac{120}{17.14} = 7.\ \text{AMPS}$$


S1
F
120V
R1
R2
R3
I=2A
I=4A
I=8A

$R_1, R_2, R_3 = ?$

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UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.14 CONSTRUCT A PARALLEL RESISTIVE CIRCUIT

---

## PERFORMANCE OBJECTIVE:

Provided with a drawing/schematic of a parallel resistive circuit, required components, wire conductors, power source, VOM, and necessary tools and materials; construct the required parallel resistive circuit. Connections should be mechanically and electrically secure, the circuit should operate as intended, and measurements of voltage, current, and resistance should be equivalent to the calculated values of the circuit. The product must be acceptable to the instructor.

## PERFORMANCE ACTIONS:

2.1401 Assemble materials required for parallel resistive circuit.

2.1402 Interpret given drawing or schematic.

2.1403 Construct the required parallel resistive circuit.

2.1404 Calculate values for the circuit.

2.1405 Using VOM and other available instruments, make measurements to check circuit calculations and operation.

## PERFORMANCE STANDARDS:

- Following a given diagram/schematic construct a parallel resistive circuit from components and materials provided so that the circuit functions as intended with voltage, current, and resistance measurements being the equivalent of calculated values.
- The wired circuit must be acceptable to the instructor.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Identify components.
- Read pictorial/drawing, schematic.
- Describe use of VOM to measure voltage, current, and resistance.
- Describe/demonstrate how to wire a parallel circuit.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

## TASK 2.15 (Optional) CONSTRUCT A CIRCUIT WITH BATTERIES WIRED IN PARALLEL

---

---

### PERFORMANCE OBJECTIVE:

Given a diagram/schematic, batteries of the same voltage, wire conductors, a VOM, and necessary tools and materials; construct a circuit with the batteries wired in parallel. Connections should be mechanically and electrically secure and the circuit should produce the desired voltage.

### PERFORMANCE ACTIONS:

2.1501 Wire batteries in parallel as required by the instructor.

2.1502 Explain resulting circuit.

2.1503 Make required circuit measurements.

### PERFORMANCE STANDARDS:

- Construct a circuit with batteries of the same voltage wired in parallel so the end result is the desired predetermined voltage.
- The circuit must be in agreement with the schematic, etc., provided and must be acceptable to the instructor.

### SUGGESTED INSTRUCTION TIME:

### RELATED TECHNICAL INFORMATION:

- Describe the characteristics of a parallel circuit.
- State factors that determine current in a battery.
- Describe how to use the VOM.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.16 DRAW A SERIES-PARALLEL RESISTANCE CIRCUIT AND CALCULATE CIRCUIT VALUES

---

## PERFORMANCE OBJECTIVE:

Provided with a source voltage, the individual values of three resistors in the circuit, and the required materials; draw a series-parallel circuit and calculate the circuit values. Calculate and note on the drawing the values for the parallel and series branch circuits. Calculations for circuit values must be 100 percent accurate according to given voltage and resistance values. The series-parallel circuit drawing must be accurate, use the proper symbols, and be acceptable to the instructor.

## PERFORMANCE ACTIONS:

2.1601 Apply applicable rules (Laws).

2.1602 Draw a series-parallel resistive circuit using information provided by the instructor.

2.1603 Calculate values of the circuit not given.

2.1604 Check calculations and findings with those of the instructor.

## PERFORMANCE STANDARDS:

- Using given circuit voltage and resistance values, draw a series-parallel circuit and calculate circuit values with 100 percent accuracy.
- The drawing and calculations must be acceptable to the instructor.

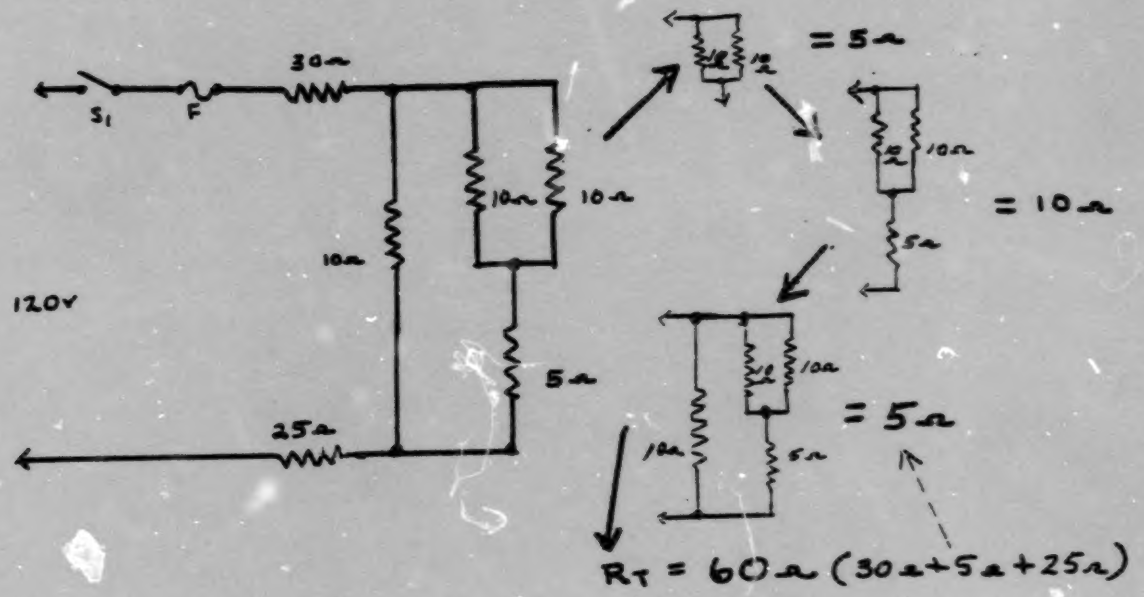
## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Describe a series-parallel circuit.
- Identify/draw series branch.
- Identify/draw parallel branch.
- Explain/demonstrate calculations required to determine circuit values.

---

RELATED TECHNICAL INFORMATION (Con't.):


30Ω
S1
F
10Ω
10Ω
10Ω
120V
5Ω
25Ω
= 5Ω
10Ω
5Ω
= 10Ω
10Ω
10Ω
5Ω
= 5Ω
RT = 60Ω (30Ω+5Ω+25Ω)

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.17 CONSTRUCT A SERIES-PARALLEL RESISTANCE CIRCUIT

PERFORMANCE OBJECTIVE:

Given a drawing/schematic of a series-parallel resistance circuit, values for circuit resistances, the circuit voltage, components, wire conductors, VOM, and other required materials and tools; construct a series-parallel resistance circuit. All connections will be mechanically and electrically secure, the circuit must operate as intended, and the voltage and current measurements must be equivalent to the calculated values of the circuit.

PERFORMANCE ACTIONS:

2.1701 Assemble materials required for series-parallel circuit.

2.1702 Wire circuit according to diagram/schematic.

2.1703 Check circuit with schematic/diagram.

2.1704 Measure circuit values.

2.1705 Check circuit measurements against calculated values.

PERFORMANCE STANDARDS:

- Construct a series-parallel circuit resistance from given information, components, and tools and, using a VOM, check to ensure that circuit measurements of voltage and current are equivalent to calculated values.
- The circuit should operate as intended and the product must be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify circuit symbols.
- Identify electrical components.
- Explain method for solving R-total.
- Describe series-parallel circuit.
- Demonstrate use of VOM.

## TASK 2.18 MEASURE RESISTANCE OF A SINGLE-PHASE COMPRESSOR

---

PERFORMANCE OBJECTIVE:

Provided with an ohmmeter (VOM) and a functional single-phase compressor; measure the resistance of the windings of the compressor. The resitance should be within a predetermined value (given by the instructor or indicated in manufacturer's data plate).

PERFORMANCE ACTIONS:

2.1801 Assemble compressor and VOM and other required materials.

2.1802 Set up VOM for resistance measurements.

2.1803 Identify compressor windings:

a. Main wiring has fewer turns of heavy wire resulting in lower resistance readings.
b. Start winding has up to 6 times the resistance of main windings.

2.1804 Make mesurements.

2.1805 Check measurements against predetermined value given by the instructor.

PERFORMANCE STANDARDS:

- Measure the resistance of a single-phase compressor using the VOM.
- Measurement should agree with predetermined value.
- Performance process and measurement finding must be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify winding marking of different compressors.
- Identify the starting winding from the run winding by resistance check (starting winding ahving more resistance).
- Explain single-phase.
- Explain three-phase.
- Describe/demonstrate use of VOM (ohmmeter) for resistance measurements.

---

EXPANDED TECHNICAL INFORMATION:

- Describe self-starting motors.
- Identify wiring block of a typical compressor (Identify the abbreviations: C, S, R).
- Describe split-phase seal motor compressor.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

## TASK 2.19 DETERMINE OPERATING CONDITION OF A COMPRESSOR USING THE HERMETIC ANALYZER*

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### PERFORMANCE OBJECTIVE:

Given a single-phase compressor and a hermetic analyzer*, check for ground, shorts, and continuity in the compressor. Determine the operating condition of the compressor.

*Or equivalent instrument(s).

### PERFORMANCE ACTIONS:

2.1901 Review TASK concerning use of Hermetic Analyzer.

2.1902 Set up Analyzer and compressor for test:

a. Remove wires form unit binding posts.
b. Analyzer master switch off, Ammeter switch off.
c. Connect leads: Red to run, white to start, black to common, green to ground.
d. Connect analyzer to power source.
e. CHECK FOR EXTERNAL GROUND:
    (1) Switch ammeter to "IN."
    (2) Observe for light indicating external ground.
    (3) Reverse plug, observe light indicator.
f. If compressor is externally grounded; move ammeter to "OFF" position. Switch voltmeter to 250 volt scale. Observe for voltage reading: Voltage reading = unit shorting by voltage to ground; replace unit.
g. If unit is not externally grounded, switch ammeter to "OFF" position. Press START button. If voltage is indicated = unit is shorting to ground.
h. Reverse master switch: Note voltmeter. If line voltage is read, windings are closed. If no voltage is present, windings are open.

### PERFORMANCE STANDARDS:

- Determine the operating condition of a Compressor using the Hermetic Analyzer, identiyfing any shorts, opens, grounds.
- Perofrmance process must be acceptable to the instructor and findings must agree with predetermined findings of the instructor.

TASK 2.19 DETERMINE OPERATING CONDITION OF A COMPRESSOR USING THE HERMETIC ANALYZER* (Con't.)

---

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe the Hermetic Analyzer.
- Demonstrate use of Hermetic Analyzer.
- Describe how to identify an open circuit.
- Describe how to identify a short circuit.
- Describe how to identify a grounded circuit.
- Identify safety considerations.

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.20 CONNECT A SINGLE-PHASE STEP-DOWN TRANSFORMER

---

## PERFORMANCE OBJECTIVE:

Provided with a wiring diagram, a single-phase transformer, a power source, a VOM, and the necessary wire conductors, connectors, and tools; connect a single-phase step-down transformer in a circuit. The transformer must be wired properly to the power source and to the remaining circuit with mechanically and electrically secure circuits.

The transformer provided should be suitable for the circuit demands.

## PERFORMANCE ACTIONS:

2.2001 Assemble necessary materials including the step-down transformer.

a. Check output of tranformer to ensure that circuit components are not damaged by excess voltage. Then, connect transformer into circuit.
b. Wire the step-down transformer in the given circuit so that the circuit operates properly. (Suggested circuit is a low voltage control system, possibly with thermostat, etc.)

2.2002 Check connections and circuit.

## PERFORMANCE STANDARDS:

- Connect a given single-phase step-down tranformer in a circuit according to diagram/schematic provided with mechanically and electrically secure connectors and meeting the instructor's standards.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Identify symbols: transformer, conductor junction, etc.
- Differentiate between AC and DC (advantages, etc.).
- Explain induction.
- Describe basic transformers and how they are used.
- Explain how transformers are constructed to step-down/up voltage.
- Describe current reaction when voltage is stepped-down.

## TASK 2.21 CONNECT A SINGLE-PHASE STEP-UP TRANSFORMER*

---

PERFORMANCE OBJECTIVE:

Provided with a wiring diagram, (or schematic), a single-phase step-up transformer, power source, wire conductors, VOM, and necessary materials and tools; connect a single-phase step-up transformer. The transformer must be properly wired to the power source, connections should be mechanically and electrically secure, and the transformer output must provide the desired voltage and current according to the transformer rating.

*(e.g., oil furnace transformer)

PERFORMANCE ACTIONS: (This is an optional task.)

2.2101 If a step-up transformer is available for a single task, follow procedures outlined by the instructor to demonstrate proper method of wiring a step-up transformer into a circuit.

2.2102 As an alternate task, if transformers are available: Wire BUCK/BOOST TRANSFORMERS (See addendum page).

2.2103 Low voltage bell transformers might be used for demonstration.

PERFORMANCE STANDARDS:

- Connect a single-phase step-up transformer in a circuit according to a given diagram/schematic to provide the voltage and current for which the circuit and transformer have been designed.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify the symbols for a step-up transformer.
- Describe the uses of a step-up transformer.
- Explain how current reacts when voltage is stepped-up
- Explain inductive reactance.
- Explain the out-of-phase condition (where current lags behind voltage) caused by inductive reactance.

## BUCK/BOOST TRANSFORMER ORIENTATION (Optional)

PURPOSE: The industrial electrician might encounter service or installation situations where the source voltage may vary as much as 20 percent from electrical equipment data plate requirement while the electrical equipment may require a supply voltage within 5 percent of requirements.

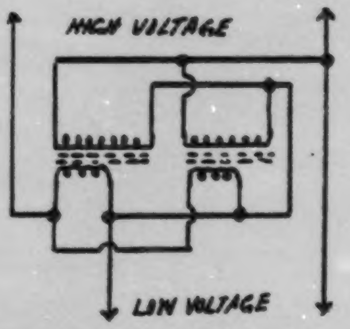
Buck/boost transformers are the solution to most cases of over or under voltage.

### BUCK/BOOST TRANSFORMER:

A low voltage signal transformer is similar to a buck/boost transformer. The buck/boost transformer typically is wound with 120/240 volt primaries and 12/24 or 16/32 volt secondaries. They are wired into a circuit so that all of the load current flows through the secondary winding before going to the load.

The resulting actions is similar to that of an auto transformer.

Look at the following diagram:



BUCK/BOOST TRANSFORMER

The load current always goes through the secondary windings but never through the primary windings. The load is connected to the low voltage for buck and to the high voltage for boost.

### BOOST:

Low voltage is wired in parallel to both the secondary and primary windings. The voltage of the load current flowing through the secondary windings is increased by the 'in phase' induction of voltage to the secondary windings from the primary windings. The amount of voltage increase is related to the ratio of turns in the primary/secondary windings and the arrangement of windings in eight series of parallel.

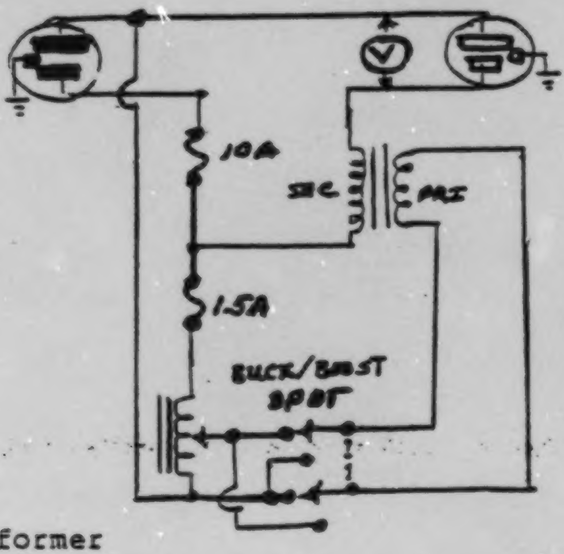
### BUCK:

High voltage is wired in series, first to the secondary windings and then to the primary windings. Load current, flowing through the secondary windings first, results in the induction current from the primary windings being slightly 'out of phase'. This bucking action produces a reduction in voltage.

## SIMPLE BUCK-BOOST CIRCUIT FOR THE SHOP

Circuit components may be substituted with suitable components available in the shop. The circuit shown should buck or boost line voltage by about 10 percent or from about 108 to about 132 volts for a 120 volt line.

Line Output



Low Voltage Transformer 120 VAC to 12 VAC, 10A

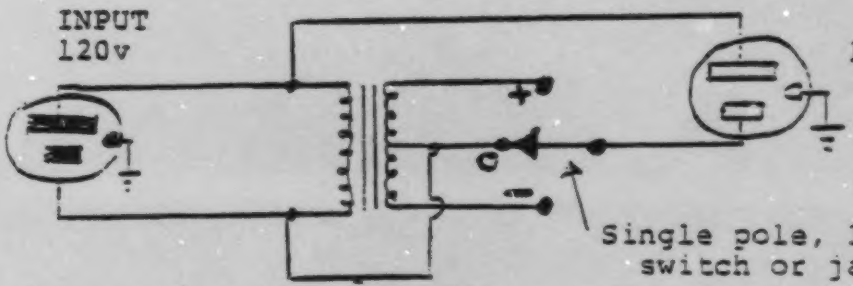
Autotransformer
120 VAC, 1.5A

Secondary of low voltage transformer is wired in series with high side of AC line. Current to load flows through the low voltage secondary and it must be rated to carry the expected load current. The DPDT switch phases the secondary of the low voltage transformer to add or subtract from the source voltage (buck or boost). The autotransformer provides a means of smoothly controlling the buck/boost. The voltmeter may be omitted.

## ALTERNATE BUCK-BOOST FOR THE SHOP/LAB

INPUT
120v

OUTPUT
110v-130v



Single pole, 3-position
switch or jacks

20v/10A Low voltage transformer

UNIT 2.0 FUNDAMENTALS OF ELECTRICITY

TASK 2.22 (Optional) CONNECT AN AUTO TRANSFORMER TO PROVIDE A VARIETY OF OUTPUT VOLTAGES

---

PERFORMANCE OBJECTIVE:

Given a wiring diagram/schematic, an auto transformer or equivalent, instructions concerning the auto transformer or equivalent method of varying an output voltage, a power source, wire conductors, VOM, and required materials and tools; connect the auto transformer to provide one or more voltage less than the line voltage. The autotransformer or substitute must be properly wired to power the power source, connections must be mechanically and electrically secure, and required voltages must be obtained and measured.

PERFORMANCE ACTIONS: (Orientation)

2.2201 If the shop has an auto transformer or the equivalent circuit, demonstrate how the auto transformer may provide a variety of output voltages.

PERFORMANCE STANDARDS:

- Connect an auto transformer or equivalent to provide a means of varying the output voltage from the line voltage.
- Connections must be properly made and the circuit operation must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe principle of auto transformer operation.
- Identify use of auto transformer (or equivalent).
- Describe how auto transformer can be used to step-up or step-down voltages.
- Identify wire size required to handle load(s).
- Identify safety considerations.

# UNIT 3.0

# BASIC REFRIGERATION

# HVAC
# BASIC REFRIGERATION
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 3.0 | BASIC REFRIGERATION | |
| 3.01 | Sketch a Basic Compression Refrigeration System | * |
| 3.02 | Install a Filter-drier | * |
| 3.03 | Install Liquid Indicator in Liquid Line | * |
| 3.04 | Front Seat, Mid Position, and Back Seat Service Valve | * |
| 3.05 | Silver Braze Saddle Valve on Suction Line | * |
| 3.06 | Install Access Core Type Service Valve | * |
| 3.07 | Explain Principles of Energy Transfer | * |
| 3.08 | Determine Pressures and Temperatures of Refrigerator | * |
| 3.09 | Determine Pressure and Temperature of an Air Conditioner | * |
| 3.10 | Determine Pressures and Temperatures on Commercial Refrigeration Systems | * |
| 3.11 | Evacuate Refrigeration System | * |
| 3.12 | Evacuate a Refrigerator | * |
| 3.13 | Evacuate a Air Conditioning System | * |
| 3.14 | Triple Evacuate a Refrigeration System | * |
| 3.15 | Compute Temperature-pressure Problems | * |

* - Total Time Estimated

| | | |
|---|---|---|
| 3.16 | Transfer Refrigerant from Storage Cylinder to Service Cylinder | * |
| 3.17 | Locate and Repair a Refrigerant Leak on a Refrigerator | * |
| 3.18 | Pressure a System with Dry Nitrogen and Refrigerant, and Locate and Repair Leak | * |
| 3.19 | Charge a Refrigerator on the Low Side of the System | * |
| 3.20 | Evacuate and Liquid Charge a Refrigeration System on the High Side | * |
| | TOTAL HOURS | 180 |

* - Total Time Estimated

TASK LISTINGS
HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 3.0 | BASIC REFRIGERATION |
| 3.01 | (SKETCH A BASIC COMPRESSION REFRIGERATION SYSTEM) Provided with the necessary drawing tools and materials and without using any references; sketch a basic compression refrigeration system. The drawing should include a compressor, condenser, evaporator, metering device, accumulator and liquid receiver. Each component will be labeled and arrows will show the direction of flow, a line drawn through the drawing will separate the high and low sides of the system. |
| 3.02 | (INSTALL A FILTER-DRIER) On a given refrigeration system with drier, using tools and materials provided; install a filter-drier. The filter-drier should allow proper refrigerant flow, the connection will form a tight seal, and the joint will be leakproof. |
| 3.03 | (INSTALL LIQUID INDICATOR IN LIQUID LINE) Given a refrigeration system, liquid indicator, flare fitting, and the necessary tools; install a liquid indicator in the liquid line. The liquid indicator will be free of restrictions, the fitting will form a tight seal and the joints will be leakproof. |
| 3.04 | (FRONT SEAT, MID POSITION, AND BACK SEAT SERVICE VALVE) Given a refrigeration sytem equipped with compressor high-side service valves and the required tools and gauges; front seat, mid position, and back seat the service valve. Back seating should give a zero reading, mid seating should provide system pressure, and in fornt seat position line should be closed. |
| 3.05 | (SILVER BRAZE SADDLE VALVE ON SUCTION LINE*) Provided with a refrigeration system saddle valve, soldering equipment and materials and the necessary tools; silver braze saddle valve on suction line. The valve will form a tight seal and the joints will be leakproof.<br>*OR, line tap service valve on straddle tube. |
| 3.06 | (INSTALL ACCESS CORE TYPE SERVICE VALVE) Given a refrigeration system, valve, and the necessary tools; install an access core type service valve. The valve will be installed in the process tube, |

the fitting will form a tight seal, and the joints will be leakproof.

3.07 (EXPLAIN PRINCIPLES OF ENERGY TRANSFER) Given a basic introduction to the principles of energy transfer and references at the instructor's discretion; explain (in one's own terminology and understanding) the Second Law of Thermodynamics, three methods by which heat may be transferred, and Charles' Law and Boyle's Law as they are related to environmental control systems.

3.08 (DETERMINE PRESSURES AND TEMPERATURES OF REFRIGERATOR) Given a refrigerator, gauge manifold set, and thermometer, determine pressures and temperatures of the refrigerator. Readings should equal to predetermined pressure and temperature conditions of refrigerator.

3.09 (DETERMINE PRESSURE AND TEMPERATURES OF AN AIR CONDITIONER) Given an air conditioning system, gauge manifold set, and thermometer; determine the pressures and temperatures of an air conditioner. Readings will be equal to predetermined pressure and temperature conditions.

3.10 (DETERMINE PRESSURES AND TEMPERATURES ON COMMERCIAL REFRIGERATION SYSTEMS) Given a commercial refrigeration system, gauges, and manifold set, and thermometer; determine pressures and temperatures on a commercial refrigeration system. Readings will be equal to predetermined pressure and temperature conditions.

3.11 (EVACUATE REFRIGERATION SYSTEM) Given a refrigeration system, refrigeration gauge set, refrigeration tools, vacuum pump, mercury manometer, equipment and materials; evacuate the sytem so that it is free of air and moisture and evacuated to 29.5 inches of mercury. Performance must be acceptable to the instructor.

3.12 (EVACUATE A REFRIGERATOR) Provided with a refrigerator, gauge and manifold set, mercury manometer, and vacuum pump; evacuate the refrigerator to 29.5 inches of mercury.

3.13 (EVACUATE AN AIR CONDITIONING SYSTEM) Provided with an air conditioning system, gauge and manifold set, vacuum pump, and electronic vacuum gauges or other instruments that may be required; evacuate the air conditioning system to 500 microns.

3.14 (TRIPLE EVACUATE A REFRIGERATION SYTEM) Given a refrigeration system, gauge and manifold set, mercury manometer, and vacuum pump; triple evacuate a refrigeration system to 29.5 inches of mercury.

3.15 (COMPUTE TEMPERATURE-PRESSURE PROBLEMS) Given temperature-pressure charts, R-12 and R-22 systems, and necessary information; compute proper pressure for each system. Pressure and temperature must correspond to normal operating temperature and pressure for each system.

3.16 (TRANSFER REFRIGERANT FORM STORAGE CYLINDER TO SERVICE CYLINDER) Provided with a storage cylinder of refrigerant, service cylinder, and the necessary tools; transfer refrigerant from storage cylinder to service cylinder. The service cylinder will be filled to 85 percent capacity.

3.17 (LOCATE AND REPAIR A REFRIGERANT LEAK ON A REFRIGERATOR) Provided with a refrigerator, a halide torch, and the required tools and equipment; locate and repair a refrigerant leak on the refrigerator so the joint will not leak.

3.18 (PRESSURIZE A SYSTEM WITH DRY NITROGEN AND REFRIGERANT, AND LOCATE AND REPAIR LEAK) Provided with a refrigeration system with a leak, nitrogen, refrigerant, and the necessary tools and materials; pressurize a system with dry nitrogen and locate and repair the leak. The system must hold pressure.

3.19 (CHARGE A REFRIGERATOR ON THE LOW SIDE OF THE SYSTEM) Provided with the refrigerator, refrigerant and the required tools and materials; charge a refrigerator on the low side of the system. The system will charge according to manufacturer's specifications for the type and amount of refrigerant.

3.20 (EVACUATE AND LIQUID CHARGE A REFRIGERATION SYTEM ON THE HIGH SIDE) Given a refrigeration system, refrigerant, and the required tools and materials; evacuate and liquid charge a system on the high side. The system will be charged to manufacturer's specifications for the type and amount of refrigerant.

TASK 3.01 SKETCH A BASIC COMPRESSION REFRIGERATION SYSTEM

---

PERFORMANCE OBJECTIVE:

Provided with necessary drawing tools and materials and without using any references; sketch a basic compression refrigeration system. The drawing should include a compressor, condenser evaporator, metering device, accumulator, and a liquid receiver. Each component will be labeled and arrows will show the direction of flow, a line drawn through the drawing will separate the high and low sides of the system.

PERFORMANCE ACTIONS:

3.0101 Draw:
- a. Evaporator-part of system where refrigerant vaporizes and absorbes heat.
- b. Condenser-system part which receives hot, high pressure refrigerant vapor from compressor and removes heat from refrigerant until it returns to liquid state.
- c. Compressor-system pump which draws a vacuum or low pressure on cooling portion of refrigerant cycle and compresses vaporized refrigerant into high pressure side of system.
- d. Metering device-regulates flow of liquid refrigerant to an evaporator and divides high from low side pressure side of system
- e. Receiver-container for storing liquid refrigerant and contains desiccants.

3.0102 Draw a line (dotted) separating the high and low sides of the system.

3.0103 Show direction of flow by arrows.

3.0104 Label each component of the system.

PERFORMANCE STANDARDS:

- Sketch a basic compression refrigeration system.
- Show the compressor, condenser, evaporator, metering device, accumulator, and a liquid receiver.
- Label each component of the system.
- Draw arrows to show the direction of flow.
- Use a line drawing through the sketch to separate the high and low sides of the system. The sketch must be acceptable to the instructor.

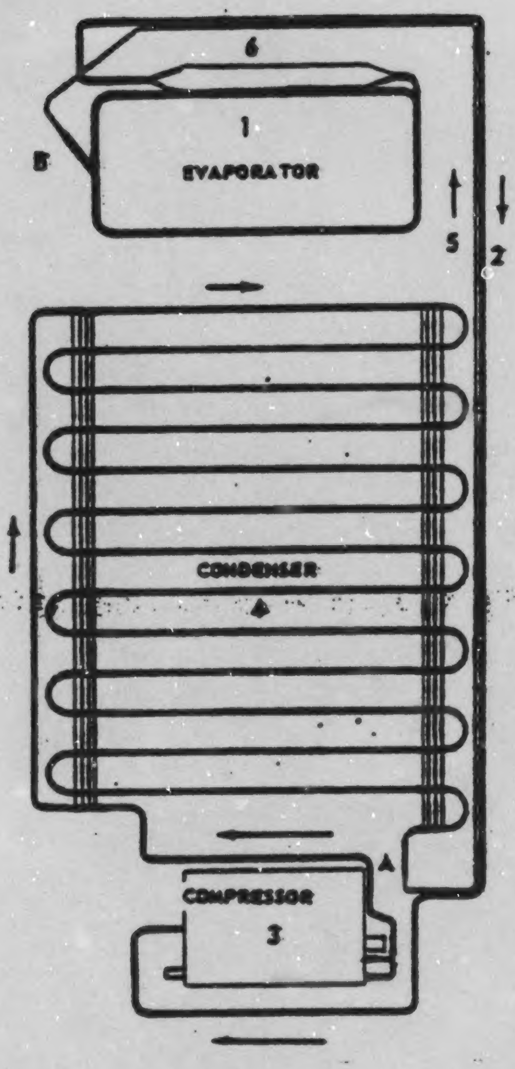
TASK 3.01 SKETCH A BASIC COMPRESSION REFRIGERATION SYSTEM (Con't.)

---

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify components of basic compression refrigeration system.
- Identify high and low side components.
- Identify and explain where change of states occur.
- Explain purpose of:
    - evaporator
    - condenser
    - compressor
    - metering device
    - liquid receiver
    - accumulator
- Explain temperature, pressure relationship of refrigerants.

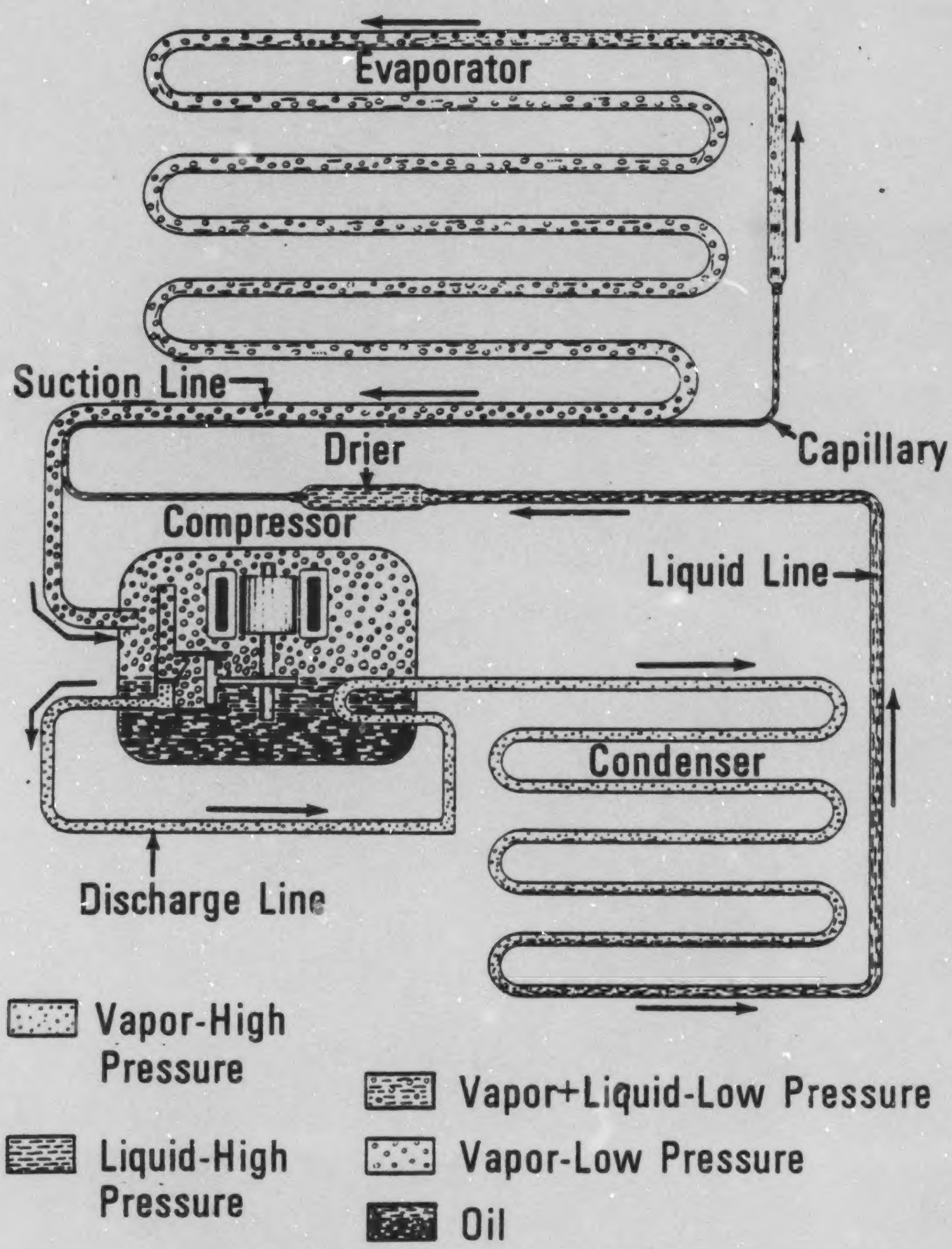

6
1
EVAPORATOR
B
5
2
CONDENSER
4
A
COMPRESSOR
3

A compression cycle showing the flow of refrigerant. 1-Evaporator. 2-Suction line. 3-Compressor. 4-Condenser. 5-Capillary tube, A to B. 6-Accumulator.

Addendum To Task 3.01

# Complete Basic Refrigeration System

## Refrigeration Cycle


Evaporator
Suction Line
Capillary
Drier
Compressor
Liquid Line
Condenser
Discharge Line
Vapor-High Pressure
Liquid-High Pressure
Vapor+Liquid-Low Pressure
Vapor-Low Pressure
Oil

UNIT 3.0 BASIC REFRIGERATION

## TASK 3.02 INSTALL A FILTER-DRIER

---

### PERFORMANCE OBJECTIVE:

On a given refrigeration system with drier, using tools and materials provided; install a filter-drier using the proper procedures for the type of filter-drier. The filter-drier should allow proper refrigerant flow, the connection will form a tight seal, and the joint will be leakproof.

### PERFORMANCE ACTIONS:

3.0201 Determine the type of filter-drier.

- a. Flare.
- b. Sweat
- c. Sweat with capillary tube.

3.0202 Assemble replacement filter-drier, tools, and materials.

3.0203 Review manufacturer's specifications.

3.0204 Pump system down, if operational.

3.0205 Remove defective part, if replacement is necessary.

3.0206 Mount filter/drier/cleanup kit.

3.0207 Joint tubing to filter-drier.

3.0208 Leak test.

3.0209 Evacuate system/line.

3.0210 Operate system.

### PERFORMANCE STANDARDS:

- Install a filter-drier in a given refrigeration sytem, using the tools and materials provided.
- The new filter-drier should allow proper refrigerant flow, the connection will form a tight seal, and the joint will be leakproof.
- Cleanup kit must be installed in direction of proper flow.

### SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Filter-drier:
    - Types of driers.
    - Sizes of driers.
    - Location of driers.
    - Purpose of driers.
    - Define desiccants.
    - Identify types of desiccants.
    - Explain location of driers.
    - Explain direction of flow and reason for arrows on driers.
    - Explain purpose of driers.
    - Explain how to size a drier for a system.
    - Explain how to leak test joint.
    - Explain the relevant safety precautions.
- Flare fittings.
- Filter-drier with sweat fittings:
    - Brazing
- Installing a capillary tube:
    - Purpose of capillary tube.
    - Direction of flow of drier.
- Procedure for checking drier restriction by checking temperature on both sides of drier (restriction reduces temperature leaving drier).
- Advantage of activated alumina desiccant: Good desiccant and good for removing acid.

## INSTALL FILTER-DRIER WITH FLARE FITTINGS

1. Put on safety glasses.
2. Install refrigeration gauge set.
3. If refrigeration system is under pressure, slowly release pressure or pump down.
4. Cut liquid line close to inlet of metering device.
5. Remove a section of liquid line the length of the filter-drier.
6. Place flare nuts on tubing.
7. Flare tubing.
8. Remove protective cap from one end of filter-drier (removing only one cap at a time...but not removing the caps until ready to install the filter-drier since the desiccant may become saturated with moisture from the air if the drier is left open).
9. Install a directional filter-drier with the refrigerant flow toward the metering device (direction of refrigerant flow should be indicated on filter-drier with an arrow, etc.).
10. Finger tighten flare nut.
11. Remove protective cap from other end of filter-drier.
12. Finger tighten flare nut
13. Place flare nut wrench on flare nut.
14. Place open-end wrench on adjacent hexagon part of filter-drier's male flare fitting.
15. Tighten both flare nuts.
16. Check for leak.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.03 INSTALL LIQUID INDICATOR IN LIQUID LINE

---

## PERFORMANCE OBJECTIVE:

Given a refrigeration system, liquid indicator, flare fitting, and the necessary tools; install a liquid indicator in the liquid line. The liquid indicator will be free of restrictions, the fitting will form a tight seal and the joints will be leakproof.

## PERFORMANCE ACTIONS: (Installing indicator with flare fittings)

3.0301 Put on safety goggles.

3.0302 Install refrigeration manifold and gauge set.

3.0303 If refrigeration system is under pressure, slowly release pressure or pump system down.

3.0304 Cut liquid line between outlet of filter-drier and inlet of metering device.

3.0305 Place flare nuts on tubing.

3.0306 Flare tubing.

3.0307 Lightly oil fittings.

3.0308 Install liquid indicator.

3.0309 Tighten flare nuts finger tight.

3.0310 Hold body of liquid indicator with open end wrench.

3.0311 Tighten flare nuts with flare nut wrench.

3.0312 Check work.

## PERFORMANCE STANDARDS:

- Install liquid indicator in the liquid line so that it is free of restrictions, has a tight seal and is leakproof.

## SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe purpose of liquid indicator.
- Identify types of liquid indicators.
- Describe steps to leak test a joint.
- Identify safety precautions.
- Sight glass will not indicate drier restriction: Sight glass upstream will indicate refrigerant shortage while on downstream may indicate refrigerant shortage or drier restriction.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.04 FRONT SEAT, MID POSITION, AND BACK SEAT SERVICE VALVE

---

PERFORMANCE OBJECTIVE:

Given a refrigeration system equipped with compressor high-side service valves and the required tools and gauges; front seat, mid position, and back seat the service valve. Back seating should give a zero reading, mid seating should provide system pressure, and in front seat position line should be closed.

Front Seated: Valve all the way in, shuts off connections between compressor and condenser.

Back Seated: Valve turned all the way out closes off connection to gauge port.

Mid-position (cracked): All positions are open.

PERFORMANCE ACTIONS: (Use stem type service valve)

3.0401 Put on safety goggles.

3.0402 Remove valve stem covers.

3.0403 Remove service port caps: If a pressure switch capillary tube is connected to service port, back seat of valve stem before removing flare nut.

3.0404 Clean around gauge ports.

3.0405 Attach gauge and manifold hoses.

3.0406 Check to be sure gauge manifold valves are closed to center port.

3.0407 Place two drops of oil on valve stems at packing nut.

3.0408 Crack service valve stems.

3.0409 Purge hose at gauge manifold connection.

3.0410 Start system.

3.0411 Allow system pressure to stabilize.

3.0412 If high side gauge vibrates excessively, back seat the discharge service valve stem until vibration stops.

PERFORMANCE ACTIONS (Con't.):

3.0413 Check pressure readings.

3.0414 Back seat service valves.

3.0415 Open refrigeration gauge set valves to release hose pressure.

3.0416 Remove gauge hoses: Plug gauge hoses or place on hose holder when not in use.

3.0417 Replace service port caps and tighten: If pressure switches are connected to valve service ports, valve stems will have to be cracked during normal operation.

3.0418 Check valve stem packing nuts for leaks.

3.0419 If leak is indicated, tighten packing nut.

3.0420 Replace valve stem caps.

PERFORMANCE STANDARDS:

- Front seat service valve so line is closed, mid-position service valve to provide system pressure, and back seat service valve for zero reading.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify types of service valves.
- Explain purpose of valves.
- Identify location of valves.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.05 SILVER BRAZE SADDLE VALVE ON SUCTION LINE*

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PERFORMANCE OBJECTIVE:

Provided with a refrigeration system saddle valve, soldering equipment and materials and the necessary tools; silver braze saddle valve on suction line. The valve will form a tight seal and the joints will be leakproof.

*Or, line tap service valve on straddle tube.

PERFORMANCE ACTIONS: (Install a line tap service valve)

3.0501 Put on safety goggles.

3.0502 Clean area on pressure stub where valve will be mounted.

3.0503 Place valve on pressure stub.

3.0504 Tighten valve onto pressure stub.

3.0505 Tighten gauge hose onto valve port.

3.0506 Check that gauge manifold valves are closed.

3.0507 Pierce pressure stub.

3.0508 Purge hose at gauge manifold connection.

3.0509 Start system.

3.0510 Check system pressures.

3.0511 Close line tap valves: If equipped with access core type valves, line tap cannot be closed manually prior to removing hoses.

3.0512 Remove hoses from line taps.

3.0513 Place pinch-off tool on pressure stub: Completely seal line prior to removing valve.

3.0514 Remove line tap valve.

3.0515 Put on welding safety goggles.

3.0516 Light pierced opening.

TASK 3.05 SILVER BRAZE SADDLE VALVE ON SUCTION LINE*

---

PERFORMANCE ACTIONS (Con't.):

| | |
|---|---|
| 3.0517 | Braze pierced opening. |
| 3.0518 | Turn off torch. |
| 3.0519 | Cool pressure stub with damp cloth. |
| 3.0520 | Remove pinch-off tool. |
| 3.0521 | Check for leaks. |

PERFORMANCE STANDARDS:

- Silver braze saddle valve on a suction line so that the valve forms a tight seal and the joints are leakproof.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe types of saddle valves.
- Explain how to locate saddle valves.
- Describe various types of brazing materials.
- Explain how to make braze joint.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.06 INSTALL ACCESS CORE TYPE SERVICE VALVE

---

PERFORMANCE OBJECTIVE:

Given a refrigeration system, valve, and the necessary tools; install an access core type service valve. The valve will be installed in the process tube, the fitting will form a tight seal, and the joints will be leakproof.

PERFORMANCE ACTIONS:

3.0601 Put on safety goggles.

3.0602 Clean area on tubing where access core type service valve is to be located.

3.0603 Remove core from valve.

3.0604 Place valve on tubing or in pressure stub.

3.0605 Apply flux to joint.

3.0606 Light and adjust torch.

3.0607 Apply heat to joint.

3.0608 Silver braze joint.

3.0609 Remove heat allowing to flow around joint.

3.0610 Turn off torch.

3.0611 Clean and cool joint.

3.0612 Replace core in valve.

3.0613 Check work.

PERFORMANCE STANDARDS:

- Install access core type service valve in process tube so the fitting forms a tight seal and the joints will be leakproof.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe various types of access valves.
- Identify location of access valves.
- Describe brazing procedures.
- Demonstrate how to braze a joint.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.07 EXPLAIN PRINCIPLES OF ENERGY TRANSFER

---

NOTE 1: This task is included since the competent air conditioning, heating, and refrigeration repairman must be able to apply the principles of energy transfer to the diagnosis, repair, and servicing of environmental control systems.

2: The Second Law of Thermodynamics governs all actions in refrigeration, heating, and air conditioning. Energy exchanges take place because of the Second Law of Thermodynamics.

PERFORMANCE OBJECTIVE:

Given a basic introduction to the principles of energy transfer and references at the instructor's discretion; explain (in one's own terminology and understanding) the Second Law of Thermodynamics, three methods by which heat may be transferred, and Charles' Law and Boyle's Law as they related to environmental control systems.

PERFORMANCE ACTIONS:

3.0701 Explain, in one's own terminology, Second Law of Thermodynamics as it relates to environmental control systems:

FOR EXAMPLE:

a. If a hot brick is placed on top of a cold brick, then after a period of time, both bricks will be at the same temperature, between the two original temperatures.

b. If insulation is inserted between the two bricks, it will take longer for the temperatures to equalize. (The energy must travel further, thus slowing down the transfer of heat.) /Surround the substance by a vacuum (consider how well the vacuum bottle keeps drinks hot) and the energy loss becomes even slower./

c. Second Law of Thermodynamics:
"Take two or more substances with different amounts of heat energy and place them so they can exchange the energy and the substance with the most energy will transfer energy to the substance with less energy until both are at the same energy level."

---

PERFORMANCE ACTIONS (Con't.):

d. Simply stated, the Second Law of Thermodynamics states: All energy eventually reaches a state of equilibrium with volumes, pressures, and temperatures interchanging until they reach a stable energy state.

3.0702 Define three ways that heat is transferred:

a. Radiation (from fire, heating element, etc.).
b. Convection (heat absorbed by fluid such as air or liquid causes the fluid to expand and become lighter than surrounding fluid, thereby causing it to move up because it is lighter, etc.).
c. Conduction (transferring of heat energy through a container as the temperature levels try to equalize).

3.0703 Explain CHARLES' LAW* (see explanation in Related Technical Information.)

[Law stated for reference.]

a. "At a constant volume, the pressure of a gas varies directly as the absolute temperature."
b. "At a constant pressure, the volume of a gas varies directly as the absolute temperature."

3.0704 Explain BOYLE'S LAW (See explanation in Related Technical Information.)

[Law stated for reference.]

a. "The volume of a gas varies inversely as the absolute pressure providing the temperature remains the constant."
b. "The absolute pressure of a gas varies inversely as the volume of providing the temperature remains constant."

PERFORMANCE STANDARDS:

- Explain the concept of Law of Thermodynamics, identify three methods of heat transfer, and explain how Charles' Law and Boyle's Law related to refrigeration, heating and air conditioning.
  (NOTE: Emphasis will be the student demonstrating a practical understanding (ability to describe in own terminology and apply theory to parctical situations) of principles of energy transfer.

---

SUGGESTED INSTRUCTION TIME:

*RELATED TECHNICAL INFORMATION:

- CHARLES' LAW (explanantion):
    a. The pressure of liquid and gas refrigerant in a container increases as the temperature increases. In a condenser or receiver container of a cooling system, the pressure is lowered as water or air of a lower temperature than the refrigerant is passed through or around the condenser tubes taking heat away form the refrigerant. Pressure thus goes down.
    b. In the evaporator cooling coil, refrigerant is found in both liquid and gas states. As air that is warmer than the liquid refrigerant in the cooling coil is passed over evaporator coils, heat is transferred from hot to cool substance. The low boiling temperature of the rerrigerant is reached and as the refrigerant becomes a vapor, is drawn away from the evaporator by the suction of the compressor. Thus the volume in the system is regulated by the size of the evaporator coil and the pressure is maintained by the suction effect of the compressor.
- BOYLE'S LAW (explanation):
    a. As the compressor piston goes down opening the chamber, it causes a vacuum in the cylinder. Refrigerant is pulled in to fill the vacuum to equalize the system. As the piston moves up, the refrigerant vapor is compressed and its volume is decreased.
    b. As the compressor piston moves up, the refrigerant changes from a low temperature, low pressure, high volume gas to a high temperature gas. The force of compressing the gas causes the heat to rise also. The high temperature gas is moved to the condenser where the heat is transferred to cooler air or water passing through/over the condenser. In the process of giving up heat, the refrigerant changes to a mixture of cooler gas and liquid it is returned to the evaporator cooling coil to be recycled again.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.08 DETERMINE PRESSURES AND TEMPERATURES OF REFRIGERATOR

---

PERFORMANCE OBJECTIVE:

Given a refrigerator, gauge manifold set, and thermometer, determine pressures and temperatures of the refrigerator. Readings should be equal to predetermined pressure and temperature conditions of refrigerator.

PERFORMANCE ACTIONS:

3.0801 Allow refrigerator to operate for about a half hour prior to taking readings.

3.0802 Locate manufacturer's data plate.

3.0803 Obtain manufacturer's name and unit model number.

3.0804 Identify type of refrigerant used.

3.0805 Place a thermometer in evaporator compartment.

3.0806 Obtain room temperature in area of refrigerator.

3.0807 Put on safety goggles.

3.0808 Use appropriate wrench to remove cap form low side service valve gauge port.

3.0809 Tighten hose from compound gauge on low service port.

3.0810 Use refrigeration ratchet to crack service valve.

3.0811 Install pressure gauge on high side in same manner as compound gauge was installed.

3.0812 Record following information:

a. Manufacturer: ______________________________
b. Unit model number: ________________________
c. Refrigerant: ______________________________
d. Evaporator temperature - __________ degrees, F
e. Low side pressure = __________ p.s.i.g.
f. High side pressure = ____________ p.s.i.g.
g. Ambient temperature = ____________degrees, F

TASK 3.08 DETERMINE PRESSURES AND TEMPERATURES OF REFRIGERATOR

---

PERFORMANCE ACTIONS (Con't.):

3.0813 Back seat service valve.

3.0814 Place cloth around hose end and gauge port as they are removed.

3.0815 Replace service port caps.

3.0816 Tighten caps finger tight followed by a slight (quarter) turn with a wrench.

3.0817 Check work.

PERFORMANCE STANDARDS:

- Determine pressures and temperatures of refrigerator.
- Readings should be equal to predetermined pressure and temperature conditions of refrigerator.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe normal operating pressures and temperatures of refrigerator.
- Demonstrate proper skill in using gauge manifold.
- Explain correct temperatures of refrigerators.
- Identify safety precautions.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.09 DETERMINE PRESSURE AND TEMPERATURE OF AN AIR CONDITIONER

---

PERFORMANCE OBJECTIVE:

Given an air conditioning system, gauge manifold set, and thermometer; determine the pressures and temperatures of and air conditioner. Readings will be equal to predetermined pressure and temperature conditions.

PERFORMANCE ACTIONS:

3.0901 Allow air conditioner to operate for about a half hour prior to taking readings.

3.0902 Locate data plate.

3.0903 Obtain manufacturer's name and unit model number.

3.0904 Identify refrigerant type used.

3.0905 Place thermometer in supply air.

3.0906 Obtaing ambient in area of condenser, avoiding discharge air from condenser.

3.0907 Put on safety goggles.

3.0908 Use open end wrench to remove cap from low side and high side service valve gauge ports.

3.0909 Tighten hose form compound gauge on low side service port.

3.0910 Use refrigeration ratchet to crack service valve.

3.0911 Install pressure gauge on high side in same manner as compound gauge was installed.

3.0912 Record following information:

a. Manufacturer: ______________________________
b. Unit model number: ________________________
c. Refrigerant: ______________________________
d. Evaporator temperature = _____________degrees, F
e. Low side pressure = _____________ p.s.i.g.
f. High side pressure = _________________p.s.i.g.
g. Ambient temperature = ______________degrees. F

3.0913 Back seat service valve.

TASK 3.09 DETERMINE PRESSURE AND TEMPERATURES OF AN AIR CONDITIONER

---

PERFORMANCE ACTIONS (Con't.):

3.0914 Use a protective cloth when removing hose and gauge port.

3.0915 Replace service port caps.

3.0916 Tighten caps finger tight, then slightly tighten (quarter turn) with a wrench.

3.0917 Check work.

PERFORMANCE STANDARDS:

- Determine pressure and temperatures of an air conditioner.
- Readings will be equal to predetermined pressure and temperature conditions.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe normal operating pressure of an air conditioner.
- Read temperature pressure chart.
- Demonstrate skill in use of gauge and manifold set.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.10 DETERMINE PRESSURES AND TEMPERATURES ON COMMERCIAL REFRIGERATION SYSTEM

---

PERFORMANCE OBJECTIVE:

Given a commercial refrigeration system, gauges and manifold set, and thermometer; determine pressures and temperatures on a commercial refrigeration system. Readings will be equal to predetermined pressure and temperature conditions.

PERFORMANCE ACTIONS:

3.1001 Allow refrigerator to operate for about a half hour prior to taking readings.

3.1002 Locate data plate.

3.1003 Obtain manufacturer's name and unit model number.

3.1004 Identify type of refirgerant.

3.1005 Place a thermometer in eveporator compartment.

3.1006 Obtain room temperature in area of refrigerator.

3.1007 Put on safety goggles.

3.1008 Use a wrench to remove cap from low side service valve gauge port.

3.1009 Tighten hose from compound gauge on low side service port.

3.1010 Use refrigeration ratchet to crack service valve.

3.1011 Install pressure gauge on high side in same manner as compound gauge was installed.

3.1012 Record following information:

a. Manufacturer: ______________________
b. Model number: ______________________
c. Refrigerant: ______________________
d. Evaporator temperature = __________ degrees, F
e. Low side pressure = __________ p.s.i.g.
f. High side pressure = __________ p.s.i.g.
g. Ambient temperature = __________ degrees, F

3.1013 Back seat service valve.

---

PERFORMANCE ACTIONS (Con't.):

3.1014 Use cloth around hose end and gauge port when removing hoses.

3.1015 Replace service port caps.

3.1016 Tighten caps finger tight, then turn with a wrench about a quarter turn.

3.1017 Check work.

PERFORMANCE STANDARDS:

- Determine pressures and temperatures on a commercial refrigeration system.
- Readings will be equal to predetermine pressure and temperature conditions.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain normal operating pressure and temperature of commercial system.
- Explain how to determine ambient temperature.
- Determine correct design temperatures of an air conditioner.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.11 EVACUATE REFRIGERATION SYSTEM

---

PERFORMANCE OBJECTIVE:

Given a refirgeration system, refirgeration gauge set, refrigeration tools, vacuum pump, mercury manometer, equipment and materials; evacuate the system so that it is free of air and moisture. and evacuated to 29.5 inches of mercury. Performance must be acceptable to the instructor.

PERFORMANCE ACTIONS:

3.1101 Attach refrigeration gauge set to system.

3.1102 Crack service valves.

3.1103 Discharge and refrigerant pressure that may exist.

3.1104 Connect gauge set center hose to vacumm pump inlet port.

3.1105 Remove cap from vacuum pump outlet port.

3.1106 Start vacuum pump.

3.1107 Open high side refrigeration gauge set valve.

3.1108 When compound gauge shows a vacuum of 5 inches Hg or more, open low side refrigeration gauge set valve.

3.1109 After a vacuum of 25 inches Hg has been reached, the mercury manometer should be used for accuracy.

3.1110 Evacuate to 29 inches Hg.

3.1111 Evacuate for approximately 20 minutes after reaching 29 inches Hg.

3.1112 Close refrigeration gauge set valves.

3.1113 Turn off vacuum pump.

3.1114 Disconnect center hose from vacuum pump.

3.1115 Connect center hose to refrigerant drum.

3.1116 Purge air from center hose.

3.1117 Open high side refrigeration gauge set valve.

TASK 3.11 EVACUATE REFRIGERATION SYSTEM

---

PERFORMANCE ACTIONS (Con't.):

| | |
|---|---|
| 3.1118 | Pressurize system to 5 p.s.i.g. |
| 3.1119 | Allow system to set for 5 minutes. |
| 3.1120 | Discharge refrigerant. |
| 3.1121 | Repeat evacuation steps one more time. |
| 3.1122 | Repeat steps for evaucation but stop after "allowing system to set for 5 minutes." (i.d., Do not discharge refrigerant.) |
| 3.1123 | Check work. |

PERFORMANCE STANDARDS:

- Evacuate a given refrigeration system to 29.5 inches of mercury.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe proper operation of vacuum pump.
- Describe how to connect gauges to a refrigeration system.
- Explain purpose of evacuating.
- Explain how to read a mercury manometer.
- Identify sources of moisture in a system.
- Explain results of moisture in a system.
- Explain vacuum measurement scale.
- Identify relevant safety precautions including use of vacuum pump.

TASK 3.12 EVACUATE A REFRIGERATOR

---

PERFORMANCE OBJECTIVE:

Provided with a refrigerator, gauge and manifold set, mercury manometer, and vacuum pump; evacuate the domestic refrigerator to 29.5 inches of mercury.

PERFORMANCE ACTIONS:

> "Follow procedures previously outlined, recommended by manufacturer, or suggested by the instructor."

PERFORMANCE STANDARDS:

- Evacuate a refrigerator to 29.5 inches of mercury.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain how to connect gauges to a refrigeration system.
- Explain purpose of evacuating.
- Explain how to read a mercury manometer.
- Identify sources of moisture in a system.
- Describe results of moisture in a system.
- Explain vacuum measurement scale.
- Identify safety precautions.

UNIT 3.0 BASIC REFRIGERATION

TASK 3.13 EVACUATE AN AIR CONDITIONING SYSTEM

---

PERFORMANCE OBJECTIVE:

Provided with an air conditioning system, gauge and manifold set, vacuum pump, and electronic vacuum gauges or other instruments that may be required; evacuate the air conditioning system to 500 microns.

PERFORMANCE ACTIONS:

> "Follow procedures previously outlined, recommended by manufacturer, or suggested by the instructor."

PERFORMANCE STANDARDS:

- Evacuate an air conditioning system to 500 microns.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe proper use of electronic vacuum gauge.
- Explain how to connect gauges to a system.
- Explain purpose of evacuating a system.
- Identify sources of moisture in a system.
- Describe results of moisture in a system.
- Explain micron vacuum scale.
- Identify safety precautions.

OPTIONAL ACTIONS: (For use of Electronic Vacuum Gauge)

1. Attach refrigeration gauge set to system.
2. Crack service valves.
3. Discharge any refrigerant pressure that may exist.
4. Connect electronic vacuum gauge to system.
5. Connect refrigeration gauge set center hose to vacuum pump inlet port.
6. Remove cap from vacuum pump outlet port.
7. Start the vacuum pump.
8. Open the high side refrigeration gauge set valve.
9. When the compound gauge shows a vacuum of 5 inches Hg or more, open the low side refrigeration gauge set valve.
10. After a vacuum of 29 inches Hg has been reached, the electronic vacuum gauge should be used for accuracy.
11. Evacuate to 500 microns.
12. Evacuate for about 20 minutes after reaching 500 microns.
13. Close refrigeration gauge set valves.
14. Turn off vacuum pump.
15. Check work.

| | |
|---|---|
| UNIT 3.0 | BASIC REFRIGERATION |
| TASK 3.14 | TRIPLE EVACUATE A REFRIGERATION SYSTEM |

---

PERFORMANCE OBJECTIVE:

Given a refrigeration system, gauge and manifold set, mercury manometer, and vacuum pump; triple evacuate a refrigeration system to 29.5 inches of mercury.

PERFORMANCE ACTIONS:

3.1401 Attach refrigeration gauge set to system.

3.1402 Crack service valves.

3.1403 Discharge any refrigerant pressure that exists.

3.1404 Connect gauge set center hose to vacuum pump inlet port.

3.1405 Remove cap from vacuum pump outlet port.

3.1406 Start the vacuum pump.

3.1407 Open the high side refrigeration gauge set valve.

3.1408 When the compound gauge shows a vacuum of 5 inches Hg or more, open the low side refrigeration gauge set valve.

3.1409 After a vacuum of 25 inches Hg has been reached, the mercury manometer should be used for accuracy.

3.1410 Evacuate to 29 inches Hg.

3.1411 Evacuate for about 20 minutes after reaching 29 inches Hg.

3.1412 Close refrigeration gauge set valves.

3.1413 Turn off the vacuum pump.

3.1414 Disconnect center hose from vacuum pump.

3.1415 Connect center hose to refrigerant drum.

3.1416 Purge air from center hose.

3.1417 Open high side refrigeration gauge set valve.

TASK 3.14 TRIPLE EVACUATE A REFRIGERATION SYSTEM

---

PERFORMANCE ACTIONS (Con't.):

| | |
|---|---|
| 3.1418 | Pressurize system to 5 p.s.i.g. |
| 3.1419 | Allow system to set for 5 minutes. |
| 3.1420 | Discharge refrigerant. |
| 3.1421 | Repeat evacuation steps (2nd time). |
| 3.1422 | Repeat evacuation steps (3rd time). |

PERFORMANCE STANDARDS:

- Triple evacuate a refrigeration system to 29.5 inches of mercury.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain purpose of triple evacuation procedures.
- Explain purpose of heat pumps added to a system.
- Explain purpose of breaking vacuum with nitrogen.
- Demonstrate triple evaculation procedure.
- Identify safety considerations.

TASK 3.15 COMPUTE TEMPERATURE-PRESSURE PROBLEMS

---

PERFORMANCE OBJECTIVE:

Given temperature-pressure charts, R-12 and R-22 systems, and necessary information; compute proper pressure for each system. Pressure and temperature must correspond to normal operating temperature and pressure for each system.

PERFORMANCE ACTIONS:

3.1501 Explain or state:

a. Temperature of refrigerant in evaporator is about 8-12 degrees F colder than evaporator when compressor is operating.
b. Temperature of refrigerant in evaporator is same as evaporator temperature when compressor is "not" operating.
c. Temperature of refrigerant in an air-cooled condenser is about 30-35 degrees F warmer than room temperature.
d. Temperature of refrigerant in a water-cooled condenser is about 20 degrees F warmer than water temperature at the drain outlet.
e. Temperature of refrigerant in the condenser will be about same as temperature of cooling medium after unit has been shut off for 15-30 minutes.

3.1502 Identify: Temperature-pressure Charts for given refrigerants (R-12, R-22, etc.).

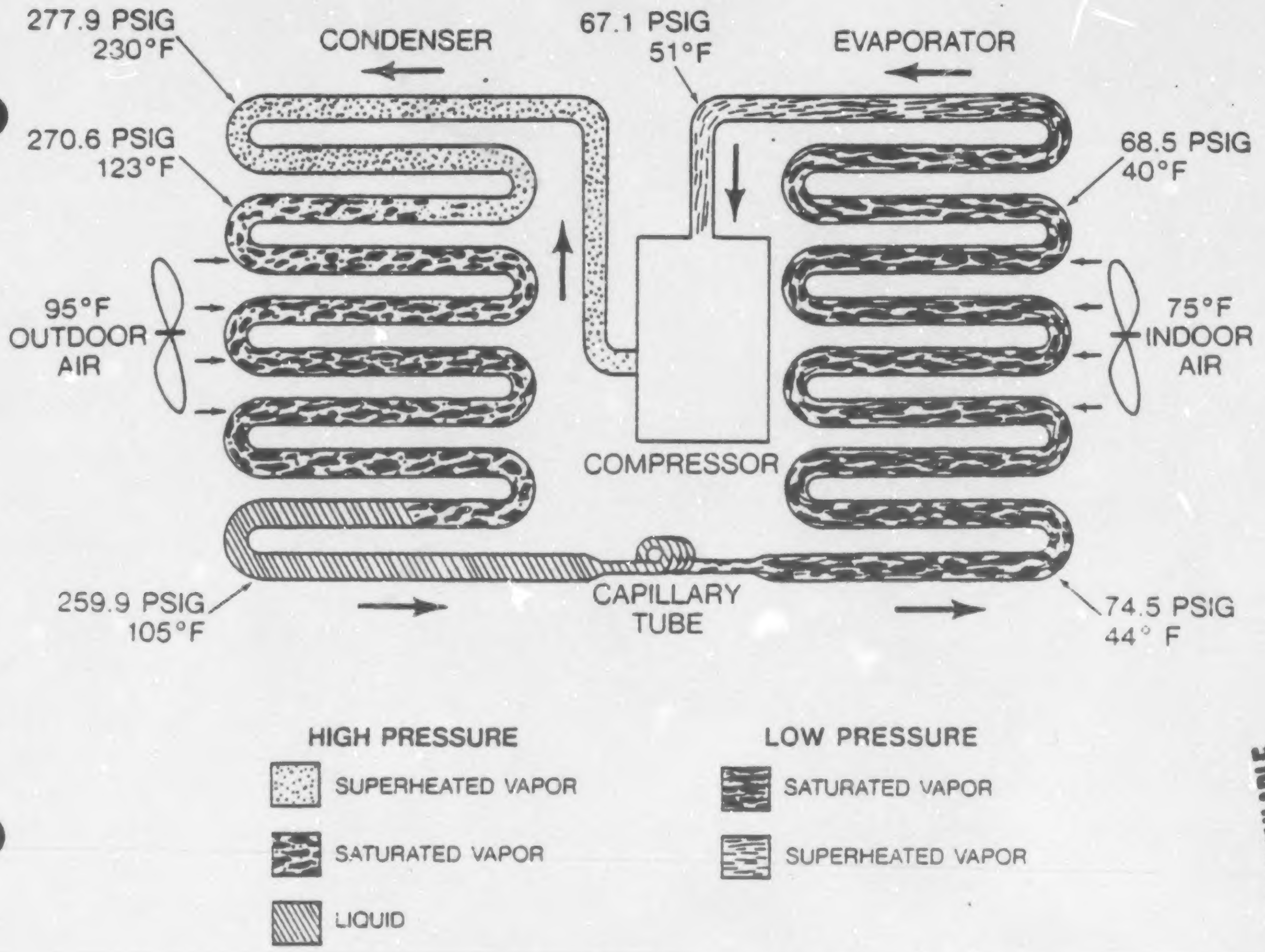
3.1503 Describe how to read Temperature-pressure Charts.

3.1504 Demonstrate ability to use Temperature-pressure Charts in a given situation. (NOTE: "To fully understand the operation of a refrigerant system, it is essential to understand the temperature-pressure characteristics of the refrigerant and to understand whether saturated vapor, liquid or superheated vapor must be present in each functioning component in the system.")

Addendum To Task 3.15

| Temp. °F. | Pressure PSIG | Temp. °F. | Pressure PSIG | Temp. °F. | Pressure PSIG | Temp. °F. | Pressure PSIG |
|---|---|---|---|---|---|---|---|
| − 40 | 0.5 | 7 | 30.0 | 34 | 60.1 | 82 | 148.4 |
| − 38 | 1.3 | 8 | 30.9 | 35 | 61.5 | 84 | 153.2 |
| − 36 | 2.2 | 9 | 31.8 | 36 | 62.8 | 86 | 158.2 |
| − 34 | 3.0 | 10 | 32.8 | 37 | 64.2 | 88 | 163.2 |
| − 32 | 3.9 | 11 | 33.7 | 38 | 65.6 | 90 | 168.4 |
| − 30 | 4.9 | 12 | 34.7 | 39 | 67.1 | 92 | 173.7 |
| − 28 | 5.8 | 13 | 35.7 | 40 | 68.5 | 94 | 179.1 |
| − 26 | 6.9 | 14 | 36.7 | 42 | 71.4 | 96 | 184.6 |
| − 24 | 7.9 | 15 | 37.7 | 44 | 74.5 | 98 | 190.2 |
| − 22 | 9.0 | 16 | 38.7 | 46 | 77.6 | 100 | 195.9 |
| − 20 | 10.1 | 17 | 39.8 | 48 | 80.8 | 102 | 201.8 |
| − 18 | 11.3 | 18 | 40.8 | 50 | 84.0 | 104 | 207.7 |
| − 16 | 12.5 | 19 | 41.9 | 52 | 87.4 | 106 | 213.8 |
| − 14 | 13.8 | 20 | 43.0 | 54 | 90.8 | 108 | 220.0 |
| − 12 | 15.1 | 21 | 44.1 | 56 | 94.3 | 110 | 226.4 |
| − 10 | 16.5 | 22 | 45.3 | 58 | 97.9 | 112 | 232.8 |
| − 8 | 17.9 | 23 | 46.4 | 60 | 101.6 | 114 | 239.4 |
| − 6 | 19.3 | 24 | 47.6 | 62 | 105.4 | 116 | 246.1 |
| − 4 | 20.8 | 25 | 48.8 | 64 | 109.3 | 118 | 252.9 |
| − 2 | 22.4 | 26 | 49.9 | 66 | 113.2 | 120 | 259.9 |
| 0 | 24.0 | 27 | 51.2 | 68 | 117.3 | 125 | 277.9 |
| 1 | 24.8 | 28 | 52.4 | 70 | 121.4 | 130 | 296.8 |
| 2 | 25.6 | 29 | 53.6 | 72 | 125.7 | 135 | 316.6 |
| 3 | 26.4 | 30 | 54.9 | 74 | 130.0 | 140 | 337.2 |
| 4 | 27.3 | 31 | 56.2 | 76 | 134.4 | 145 | 358.9 |
| 5 | 28.2 | 32 | 57.5 | 78 | 139.0 | 150 | 381.5 |
| 6 | 29.1 | 33 | 58.8 | 80 | 143.6 | 155 | 405.1 |

TEMPERATURE PRESSURE CHART (REFRIGERANT 22)


277.9 PSIG
230°F
CONDENSER
67.1 PSIG
51°F
EVAPORATOR
270.6 PSIG
123°F
68.5 PSIG
40°F
95°F
OUTDOOR
AIR
75°F
INDOOR
AIR
COMPRESSOR
259.9 PSIG
105°F
CAPILLARY
TUBE
74.5 PSIG
44° F
HIGH PRESSURE
SUPERHEATED VAPOR
SATURATED VAPOR
LIQUID
LOW PRESSURE
SATURATED VAPOR
SUPERHEATED VAPOR

TYPICAL OPERATING SYSTEM

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PERFORMANCE STANDARDS:

- Compute temperature-pressure problems for given R-12 and R-22 systems, so that pressure and temperature correspond to normal operating temperature and pressure for each system.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe operating pressure and temperature in a normal system.
- Demonstrate ability to properly use pressure-temperature chart.
- Explain procedure for measuring ambient temperature.

ADDENDUM PAGE ACCOMPANIES THIS TASK:

1. Temperature-pressure Chart for Refrigerant 22 (sample)
2. Application on a typical operation system (example)

EXPLANATION OF TEMPERATURE-PRESSURE CHART:

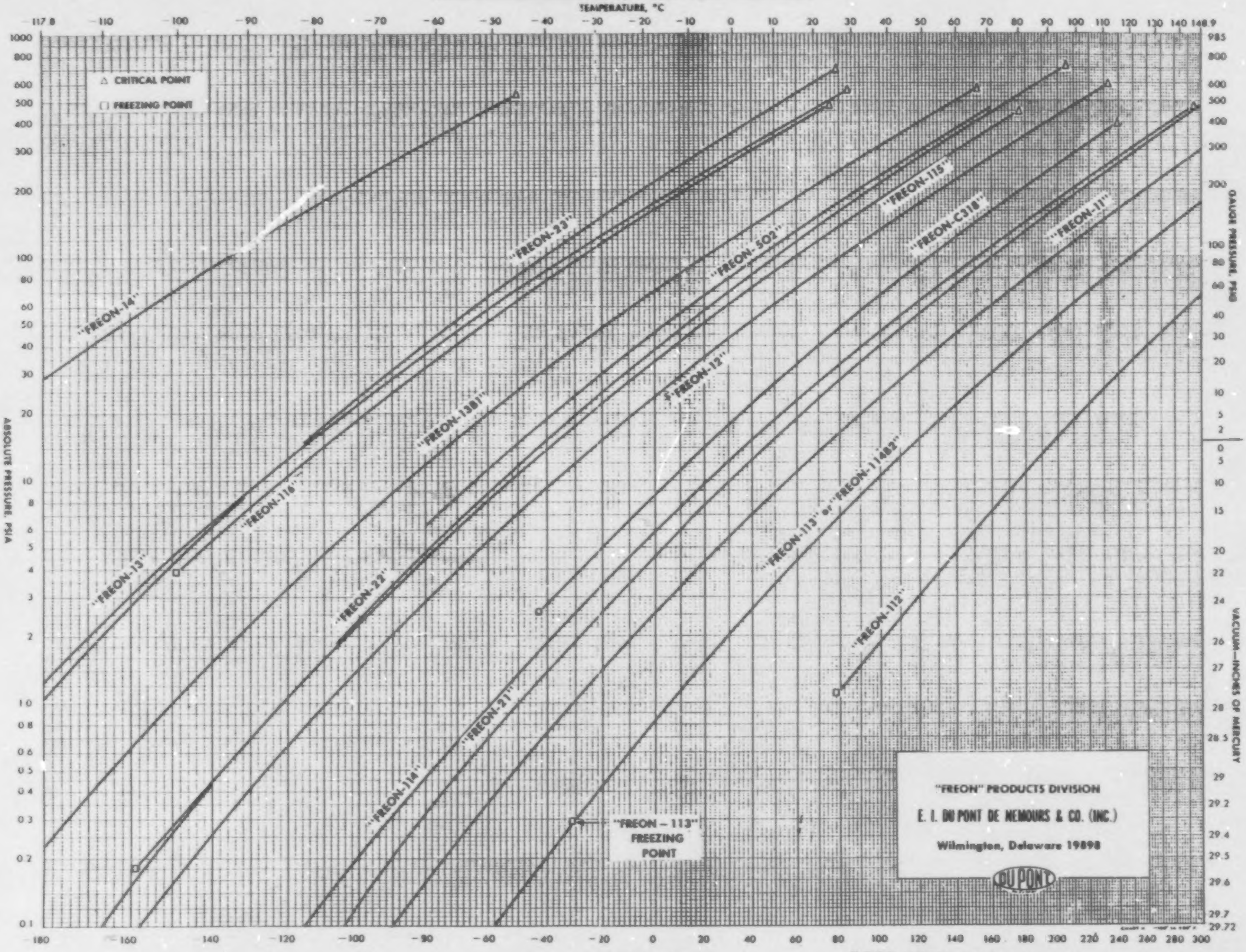
1. A temperature-pressure chart for a given refrigerant (e.g., R-12) list temperatures of the refrigerant in a saturated vapor state at various pressures. The chart is based on the refrigerant containing some liquid and some vapor relationship.
2. See R-22 Temperature-pressure Chart (Addendum page)
3. Example:
   a. R-22 @ 195.9 PSIG and 100 degrees F = saturated vapor
   b. R-22 @ 195.9 PSIG and 80 degrees F = 20 degrees supercooled liquid
   c. R-22 @ 195.9 PSIG and 120 degrees F = 20 degrees superheated vapor
4. See typical operating system diagram on addendum page.
5. Analysis of operating system (Refer to diagram):
   a. A compressor maintains a pressure differentail in the system so there will be constant flow of refrigerant.
   b. The condenser must transfer the total system heat into the air, water, or other media; condense and subcool the refrigerant; and maintain adequate pressure to supply refrigerant requirements of evaporator.

EXPLANATION OF TEMPERATURE-PRESSURE CHART (Con't.):

c. An expansion device controls the pressure at the evaporator inlet to produce a saturated vapor temperature below the air temperature crossing the evaporator, and above the freezing temperature of water forming on the evaporator coil.

d. The refrigerant leaving the evaporator and entering the compressor must be a superheated vapor to prevent compressor damage. Suction line superheat is controlled by the refrigerant charge in a capillary tube or metering orifice device. Expansion valves maintain a constant superheat in the suction line.

PRESSURE-TEMPERATURE RELATIONSHIPS OF "FREON" COMPOUNDS



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Addendum To Task 3.15

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UNIT 3.0 BASIC REFRIGERATION

TASK 3.16 TRANSFER REFRIGERANT FROM STORAGE CYLINDER TO SERVICE CYLINDER

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PERFORMANCE OBJECTIVE:

Provided with a storage cylinder of refrigerant, service cylinder, and the necessary tools; transfer refrigerant from storage cylinder to service cylinder. The service cylinder will be filled to 85 percent capacity.

PERFORMANCE ACTIONS:

3.1601 Review precautions in handling refrigerants including (a) handling refrigerant cylinders, (b) first aid if refrigerant exposed to skin or eye, and (c) techniques of handling refrigerants.

3.1602 Cool small cylinder in freezer or by use of ice, etc.

3.1603 Invert larger cylinder.

3.1604 Remove cylinder valve cap.

3.1605 Install cylinder adaptor (1/4 inch flare).

3.1606 Place small receiving cylinder on a scale at a lower altitude than large cylinder.

3.1607 Connect two cylinders with charging line, leaving connections slightly loose on small cylinder.

3.1608 Crack and close valve on large cylinder and tighten loose fitting (removing air from charging line).

3.1609 Open valve on large inverted cylinder and check for leaks.

3.1610 Open valve on small cylinder.

3.1611 Watch scale for required pounds of refrigerant in small cylinder filling to about 85 percent full.

3.1612 Close valve on large drum.

3.1613 War charging line slightly.

TASK 3.16 TRANSFER REFRIGERANT FROM STORAGE CYLINDER TO SERVICE CYLINDER

---

PERFORMANCE ACTIONS (Con't.):

3.1614 Close valve on small cylinder.

3.1615 Remove charging line.

3.1616 Cap cylinder opening.

3.1617 Test both cylinders for leaks.

PERFORMANCE STANDARDS:

- Transfer refrigerant from storage cylinder to fill service cylinder to 85 percent capacity.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how to identify cylinder capacity.
- Accurately identify cylinder capacity.
- Identify safety considerations in transferring and handling refrigerant, including:

1. Don't drop cylinder or strike them together violently.
2. Use a safer cradle in lifting cylinders so they will not drop.
3. Except when cylinders are in use, keep caps on cylinders where applicable.
4. Do not overfill cylinders. Weight cylinder being filled and remaining refrigerant in main cylinder.
5. Do not mix different gases in a cylinder.
6. Do not roll cylinders or use them for supports, etc.
7. Do not alter/tamper with safety devices on cylinders.
8. Open cylinder valves slowly using proper tools only.
9. Do not damage threads on regulators or other joints by forcing a fit.
10. Use regulators and pressure gauges with the proper types of gases.
11. Do not repair cylinders.
12. Do not store cylinders near flammable substances, such as oil, gasoline, waste, etc.
13. Cylinders should not be exposed to dampness, corrosive agents, etc.
14. Store full and empty cylinders apart to prevent confusion.
15. Protect cylinders from objects or actions that might damage the surface of the cylinder metal.

UNIT 3.0 BASIC REFRIGERATION-SERVICE

TASK 3.17 LOCATE AND REPAIR A REFRIGERANT LEAK ON A REFRIGERATOR

---

PERFORMANCE OBJECTIVE:

Provided with a refrigerator, a halide torch, and the required tools and equipment; locate and repair a refrigerant leak on a refrigerator so that the joint will not leak.

PERFORMANCE ACTIONS: (Pressure and leak test)

3.1701 Connect refrigeration gauge set to refrigeration system.

3.1702 Crack service valve.

3.1703 Allow pressures to equalize: Effective leak checking requires about 50 p.s.i.g. or more of pressure.

3.1704 Locate suspected leak areas.

3.1705 Light and adjust halide torch.

3.1706 Hold sniffer hose of torch to trap refrigerant.

3.1707 Move sniffer hose slowly underneath suspected leak area.

3.1708 Look for color change in torch flame to indicate a leak.

3.1709 Recheck leak with soap solution.

3.1710 Remove soap solution.

3.1711 Mark leaking area for repair.

PERFORMANCE STANDARDS:

- Locate and repair a refrigerant leak on a refrigerator so the joint will not leak pressurizing the system, checking it with the halide torch, and verifying the leak.

SUGGESTED INSTRUCTION TIME:

TASK 3.17 LOCATE AND REPAIR A REFRIGERANT LEAK ON A DOMESTIC REFRIGERATOR (Con't.)

RELATED TECHNICAL INFORMATION:

- Explain how to light and adjust the halide torch.
- Explain how to use the halide torch.
- Describe how to adjust a typical electronic leak detector.
- Identify four basic methods of leak detection:
    a. Soap solution test.
    b. Halide torch.
    c. Electronic leak detector.
    d. Suspected area enclosed in cellophane.
- Demonstrate the procedures for using the halide torch.
- Identify safety considerations. (Provide for ventilation, explain dangers of phosgene gas).

EXPANDED TASK:

- "Check leak with soapy solution:"
    - Connect refrigeration gauge set to system.
    - Crack service valves.
    - Allow pressure to equalize (positive pressure).
    - Locate suspected leaks.
    - Apply soapy solution.
    - Look for bubbles at leak indication.
    - Remove soap solution to prevent corrosion.

UNIT 3.0 BASIC REFRIGERATION-SERVICE

TASK 3.18 PRESSURIZE A SYSTEM WITH DRY NITROGEN AND REFRIGERANT, AND LOCATE AND REPAIR LEAK

---

PERFORMANCE OBJECTIVE:

Provided with a refrigeration system with a small leak, nitrogen, refrigerant, and the necessary tools and materials; pressurize a system with dry nitrogen and locate and repair the leak. The system must hold pressure.

PERFORMANCE ACTIONS:

3.1801 Connect refrigerant gauge set to refrigerant system.

3.1802 Crack service valves.

3.1803 Attach refrigerant cylinder to center hose of gauge set.

3.1804 Leave refrigerant cylinder in upright position.

3.1805 Open refrigerant cylinder valve.

3.1806 Open valve on high side of gauge manifold.

3.1807 Allow refrigerant pressure to equalize at 50 p.s.i.g.

3.1808 Close high side manifold valve.

3.1809 Close refrigerant cylinder valve.

3.1810 Loosen refrigerant hose at cylinder valve.

3.1811 Allow hose pressure to escape.

3.1812 Remove hose from refrigerant cylinder.

3.1813 Attach gauge set center hose to nitrogen regulator.

3.1814 Check to be sure regulator adjusting screw is not turned in.

3.1815 Crack nitrogen cylinder valve 1/4 turn.

3.1816 Purge center hose.

UNIT 3.0 BASIC REFRIGERATION-SERVICE

TASK 3.18 PRESSURIZE A SYSTEM WITH DRY NITROGEN AND REFRIGERANT, AND LOCATE AND REPAIR LEAK

---

PERFORMANCE ACTIONS (Con't.):

3.1817 Turn regulator and adjusting screw clockwise until desired pressure is obtained (about 100 p.s.i.g.).

3.1818 Open valve on high side of gauge manifold.

3.1819 Allow high side and low side pressures to equalize.

3.1820 Leak check system with halide torch or electronic leak detector.

3.1821 Mark leak detected.

PERFORMANCE STANDARDS:

- Pressurize a system with dry nitrogen and refrigerant, and locate and repair leaks.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe use of nitrogen and refrigerant in system.
- Identify three types of leak detection devices.
- Describe how to adjust nitrogen regulator.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION-SERVICE

TASK 3.19 CHARGE A REFRIGERATOR
ON THE LOW SIDE OF THE SYSTEM

---

PERFORMANCE OBJECTIVE:

Provided with a refrigerator, refrigerant, and the required tools and materials; charge the refrigerator on the low side of the system. The system will charge according to manufacturer's specifications for the type and amount of refrigerant.

PERFORMANCE ACTIONS: (Low side vapor charging)

3.1901 Connect refrigeration gauge set to system.

3.1902 Attach center hose to refrigerant cylinder.

3.1903 Set cylinder in upright position on scales.

3.1904 Open cylinder valve.

3.1905 Open refrigeration gauge set valves.

3.1906 Purge refrigerant hoses at service valve gauge ports (take safety precautions to prevent refrigerant from contacting eyes or skin).

3.1907 Close refrigeration gauge set valves.

3.1908 Crack service valves.

3.1909 Record weight of refrigerant cylinder.

3.1910 Open high side refrigerant set valve.

3.1911 Allow vapor to enter the system until the pressure equalizes.

3.1912 Close high side refrigeration gauge set valve.

3.1913 Start system.

3.1914 Allow system to operate so pressures may stabilize. (Check for low pressure safety switch and take proper action if unit is so equipped.)

3.1914 Crack low side refrigeration gauge set valve allowing refrigerant to enter system.

3.1915 Allow gauge pressure reading to increase 20-30 p.s.i.g.

UNIT 3.0 BASIC REFRIGERATION-SERVICE

TASK 3.19 CHARGE A REFRIGERATOR ON THE LOW SIDE OF THE SYSTEM

---

PERFORMANCE ACTIONS (Con't.):

3.1916 Use pressure-temperature chart to determine approximate pressure.

3.1917 After pressures have been reached, stop charging.

3.1918 Allow system to operate so pressures may stabilize.

3.1919 Recheck pressures.

3.1920 Add more refrigerant, as necessary.

3.1921 Back seat valves.

3.1922 Close refrigerant cylinder valve.

3.1923 Record cylinder weight to determine amount of refrigerant that has bee dispensed.

3.1924 Purge gauge set hoses.

3.1925 Remove gauge set and plug hoses.

3.1926 Replace and tighten all valve caps.

3.1927 Check work, clean up, store tools and supplies.

PERFORMANCE STANDARDS:

- Charge a refrigerator on the low side of the system according to manufacturer's specifications for the type and amount of refrigerant.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how to charge a system.
- Identify typical types of refrigerants.
- Describe how to use a charging cylinder.
- Decribe how to use a gauge and manifold set.
- Explain how to determine correct high and low side pressure.
- Identify safety considerations.
- Identify disadvantages of low side vapor charging:
    - slow
    - high drum pressure might wash out compressor oil.
- Identify advantages of low side vapor charging:
    - easy method of adding refrigerant to charged system.

UNIT 3.0 BASIC REFRIGERATION-SERVICE

TASK 3.20 EVACUATE AND LIQUID CHARGE A REFRIGERATION SYSTEM ON THE HIGH SIDE

---

PERFORMANCE OBJECTIVE:

Given a refrigeration system, refrigerant, and the required tools and materials; evacuate and liquid charge a system on the high side. The system will be charged to manufacturer's specifications for the type and amount of refrigerant.

PERFORMANCE ACTIONS: (High side liquid charging)

3.2001 Determine if high side liquid charging is to be at (a) discharge service valve of (b) king valve.

3.2002 Connect refrigeration gauge set to system.

3.2003 Attach center hose to refrigerant cylinder.

3.2004 Set cylinder in upright position on scales.

3.2005 Open cylinder valve.

3.2006 Open refrigeration gauge set valves.

3.2007 Purge refrigerant hoses at service valve gauge ports taking safety precautions to prevent refrigerant from contacting eyes or skin.

3.2008 Close refrigeration gauge set valves.

3.2009 Crack service valves.

3.2010 Record weight of refrigerant cylinder.

3.2011 Invert refrigerant cylinder.

3.2012 Open high side refrigeration gauge set valve.

3.2013 Allow liquid refrigerant to center system.

3.2014 Watch refrigerant scales.

3.2015 Close gauge set valve when desired amount of refrigerant has entered the system.

3.2016 Start and allow system to operate so pressures may stabilize.

TASK 3.20 EVACUATE AND LIQUID CHARGE A REFRIGERATION SYSTEM ON THE HIGH SIDE

---

PERFORMANCE ACTIONS (Con't.):

3.2017 Check for following incidators that additional refrigerant is needed:

a. Bubbles in sight glass.
b. Low pressure readings.
c. Frost line on evaporator.

3.2018 Additional refrigerant must be added in vapor state (See previous task).

3.2019 Note amount of liquid refrigerant used.

3.2020 Back seat service valves.

3.2021 Purge hoses of refrigerant by opening manifold valves and allowing refrigerant to discharge through center hose (access core valves do not premit purging of refrigerant).

3.2022 Remove gauge set and plug hoses.

3.2023 Replace and tighten all valve caps.

3.2034 Check work, clean up, store tools and material, etc.

PERFORMANCE STANDARDS:

- Evacuate and liquid charge a refrigeration system on the high side according to manufacturer's specifications for the type and amount of refrigerant.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how to charge a system on the high side.
- Identify refrigerants.
- Explain hazards of liquid refrigerants.
- Describe use of king valve.
- Identify safety considerations.

UNIT 3.0 BASIC REFRIGERATION

ADDENDUM DESCRIBE COMMONLY USED REFRIGERANTS

---

PERFORMANCE OBJECTIVE:

Given instruction, orientation to commmonly used refrigerants in residential and commercial systems, identify and describe distinguishing characteristics and properties of identified refrigerants such as R-12 (F-12*), R-22 (F-22), and R-502 (F-502).

* -R and-F as designations for refrigerant are interchangeable.

PERFORMANCE ACTIONS:

3.001 Identify common refrigerants such as:
- a. R-12
- b. R-22
- c. R-502
- d. Other refrigerants such as Ammonia ($NH_3$)

3.002 Identify characteristics of above refrigerants:

| REFRIGERANT | BOILING POINT DEG. F | HEAT VAPORIZATION @ BOILING POINT BTU/LB. (1 ATMOS.) |
|---|---|---|
| R-12 ($CCI_2F$) | -21.7 | 71.04 |
| R-22 ($CHCIF_2$) | -41.4 | 100.45 |
| R-502 | -50.1 | 76.46 |

3.003 Discuss above Types of Freon (Introductory Level):
- a. Freon-12:
  - (1) Most widely known of Freon refrigerants.
  - (2) Principally used in household and commercial refrigeration and air conditioning units. Types of application: Refrigerators, freezers, ice cream cabinets, food locker plants, water coolers, room air conditioners, etc.
  - (3) The use in larger air conditioning and process cooling is increasing.
- b. Freon-22:
  - (1) General use in household and commercial refrigeration and air conditioning using reciprocating compressors.
  - (2) Permits use of smaller equipment than is possible with similar refrigerants.
- c. Freon-502:
  - (1) Mixture of Freon-22 and Freon-115.
  - (2) Achieves capacity of Freon-22 with discharge temperatures comparable to Freon-12.
  - (3) Finding new reciprocating compressor applications in low-temperature display cabinets and storing and freezing food.

PERFORMANCE ACTIONS (Con't.):

3.004 Describe properties of Freons:

a. General: Colorless, almost odorless, boiling points vary widely, nontoxic, noncorrosive, nonirritating, and nonflammable under all conditions of usage. Prepared by replacing chlorine or hydrogen with flourine. Inert and thermally stable up to temperatures far beyond normal operational conditions.

b. Physical:

c. Freon Circulated: Because of low heat value, a greater volume of liquid must be circulated per unit of time to produce the desired amount of refrigeration: Generally considered and advantage in small systems.

d. Volume (Piston) Displacement: Volume of gas which must be compressed per unit of time for given refrigerating effect should, in general, be as low as possible for considerations of compactness, cost of equipment, reduction of friction, and compressor speed. (Freon-12 allows use of compact rotary compressors in commercial sizes.)

3.005 Explain operating pressures of Freons:

a. Condensing Pressure (high-side): Relationship to system construction (power consumption, compactness, and installation as well as toxicity and fire hazard standpoints).

b. Evaporating Pressure (low-side): Considerations.

c. Introduction to Pressure-Temperature Chart.

d. Describe how to read the Pressure-Temperature Chart.

3.006 Discuss (Introductory Level) Refrigerant Characteristi

a. Critical Temperature (highest temperature at which refrigerant can be condensed to a liquid). About 130°F with air cooled condensers.

b. Latent Heat of Evaporation - Quantity of heat required to change one pound of liquid into a vapor with no change in temperature.

c. Specific Heat - Quantity of heat required to raise temperature of a definite mass of a material a definite amount compared to that required to raise temperature.

d. Power Consumption - Two factors which increase power requirement vary in importance with differer refrigerants.

e. Volume of Liquid Circulated - Volume of liquid required to be circulated for a given refrigerant effect should be low to avoid fluid flow (pressure drop) problems and to keep down size of required refrigerant change.

UNIT 3.0 BASIC REFRIGERATION

ADDENDUM DESCRIBE COMMMONLY USED REFRIGERANTS

---

PERFORMANCE STANDARDS:

- Identify and describe distinguishing characteristics and properties of identified refrigerants such as R-12, R-22, and R-502 as required by the instructor.

SUGGESTED INSTRUCTION TIME: Integrated Training (Orientation in Basic Refrigeration and knowledge/ skill development in later units.)

RELATED TECHNICAL INFORMATION:

- Handling refrigerants.
- Storing and handling refrigerant cylinders.
- Cylinder capacity.
- First Aid.

APPLIES TO UNITS 4-7

## ORIENTATION TO HVAC HAND TOOLS, EQUIPMENT, TEST INSTRUMENTS AND BENCHWORK USING HAND TOOLS

For the purpose of training, the following four units concerning HVAC hand tools, special tools and equipment, test instruments, and benchwork using hand tools may be grouped together, possibly as a module. Modules have not been used in this articulated, performance-based instruction guide to simplify guide organization.

The instructor may elect to introduce specific hand tools, equipment, or instruments, and benshwork use of hand tools as total module instruction or may as parts of servicing specific equipment, etc. HVAC tools and equipment may be introduced early during the first year and skill development may occur later during the two year training period.

Related units that are designed to introduce typical equipment that the HVAC maechanic may use on the job include:

UNIT 4 HAND TOOLS

UNIT 5 HVAC BENCHWORK USING HANDTOOLS

UNIT 6 HVAC SPECIAL TOOLS AND EQUIPMENT

UNIT 7 TEST INSTRUMENTS

# STANDARDS

Standards for units concerning HVAC hand tools and test instruments are based on the following publications:

Proper Use and Care of Hand Tools, Pliers, Screwdrivers, Wrenches, Striking & Struck Tools. Chicago, IL: Klein Tools, Inc., 1977. (Free publication available in quantity to vocational programs.)

Test Instruments and Tools Used in HVAC Servicing and Troubleshooting, Dallas, TX: Lennox Industries Inc. (Education Department), ca. 1980.

Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. Modern Refrigeration and Air Conditioning. South Holland, IL: The Goodheart-Willcox Company, Inc., 1982.

Lang, V. Paul. Air Conditions: Procedures and Installation. Albany, NY: Delmar Publishers Inc., 1982.

Miller, Rex. Refrigeration and Air Conditioning Technology. Peoria, IL: Bennett Publishing Company, 1983.

Wantiez, Gary W. Air Conditioning and Refrigeration. Book One, Stillwater, OK: Mid-American Vocational Curriculm Consortium, 1977.

Other sources of standards may be substituted and may be more applicable. These sources, however, were available and appeared to represent most of the hand tools, special tools and equipment, and test instruments typically used by the HVAC mechanic.

Outcome-referenced test accompanying these units may use visuals provided by manufacturers and may use some of the latest types of special tools or test instruments.

# UNIT 4.0

## HAND TOOLS

The purpose of this unit is to introduce the air conditioning, refrigeration, and heating program student to common HVAC mechanic tools. The student should be able to identify the tools using the proper terminology and should be able to care for and properly use the hand tools upon completing this unit. The student may not develop competency in use of the hand tools until adequate practice has been acquired in the shop.

See the following unit, HVAC Benchwork Using Hand Tools, for related training.

# HVAC
# HAND TOOLS
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | | SUGGESTED HOURS |
|---|---|---|---|
| Unit | 4.0 | HAND TOOLS | |
| | 4.01 | Care for Hand Tools | * |
| | 4.02 | Properly Use Hand Tools for Assembly/Disassembly | * |
| | 4.03 | Using Hand Hacksaw, Cut Given Material in Required Time | * |
| | 4.04 | Drill Holes with Portable Drill | * |
| | 4.05 | Use Additional Hand Tools | * |
| | | TOTAL HOURS | 15 |

* - Total Time Estimated

## TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 4.0 | HAND TOOLS |
| 4.01 | (CARE FOR HAND TOOLS) Given a tool box or set of typical hand tools used in HVAC mechanics, manufacturer's standards (or equivalent) concerning proper use and care of hand tools; inspect and care for hand tools to given instructions/specifications. |
| 4.02 | (PROPERLY USE HAND TOOLS FOR ASSEMBLY/DISASSEMBLY) Given basic hand tools used in HVAC mechanic work and a job requiring use of hand tools; properly select, use, and care for basic hand tools including hammers, screwdrivers, wrenches, pliers, and other tools. |
| 4.03 | (USING HAND HACKSAW, CUT GIVEN MATERIAL IN REQUIRED TIME) Furnished with blueprint/drawing/specifications, and hand hacksaw; hacksaw the metal in a given time to within 1/32 inch outside of scribed line. |
| 4.04 | (DRILL HOLES WITH PORTABLE DRILL) Given metal or wood to drill, specifications or instructions concerning drilling, locations already marked, and the necessary tools and equipment; drill the work as required to a tolerance of +/- 1/64 inch or specifications. |
| 4.05 | (USE ADDITIONAL HAND TOOLS) Given tool box or access to additional tools such as wire brushes, feeler gauges, files, fuse pullers, crimpers, metal cutting/working snips and tools, pop riveter, and other tool; demonstrate proper method of identification, use and care of these tool to the standards of the instructor. |

UNIT 4.0 HAND TOOLS

TASK 4.01 CARE FOR HAND TOOLS

---

PERFORMANCE OBJECTIVE:

Given a tool box or set of typical hand tools used in HVAC mechanics, manufacturer's standards (or equivalent) concerning proper use and care of hand tools; inspect and care for hand tools to given instructions/specifications.

PERFORMANCE ACTIONS:

4.0101 Inspect hand tools and determine damage, if any:

- a. Cutting tools must be sharp with no broken teeth.
- b. Clamping tools must have clean jaws and screws.
- c. Soft jaws must be available for vises.
- d. Screwdrivers must have correctly shaped blades.
- e. Punches and chisels must not have mushroomed heads.

4.0102 Obtain any needed parts for repair of hand tools:

- a. Dismantel and replace damaged parts.
- b. Make required adjustments.

4.0103 Sharpen dull tools:

- a. Check for mushroomed heads.
- b. Check angle of cutting edge.
- c. Regrind shape as required.

PERFORMANCE STANDARDS:

- For given hand tools, demonstrate proper use and care of tools such as pliers, screwdrivers, wrenches, striking and struck tools to the manufacturer's or instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- NOTE: Proper care for many of the hand tools used by the HVAC mechanic are covered in the following publication which may be referred to for standards:

  Proper Use and Care of Hand Tools, Pliers, Screwdrivers, Wrenches, Striking & Struck Tools. Chicago, IL: Klein Tools, Inc., 1977. (Available free in quantities to vocational education programs.)
- Safety.
- Manufacturer's standards for care of hand tools.

UNIT 4.0 HAND TOOLS

TASK 4.02 PROPERLY USE HAND TOOLS FOR ASSEMBLY/DISASSEMBLY

---

PERFORMANCE OBJECTIVE:

Given basic hand tools used in HVAC mechanic work and a job requiring use of hand tools; properly select, use, and care for basic hand tools including hammers, screwdrivers, wrenches, pliers, and other tools.

PERFORMANCE ACTIONS:

4.0201 Properly select (identify) and demonstrate use and care of ball peen hammer, claw hammer, and other hammers as required (such as setting or plastic tip hammers or mallets):

a. Describe hammer safety.
b. Select proper hammer for given tasks.

4.0202 Properly select and demonstrate use and care of screwdriver:

a. Identify basic types of screwdrivers.
b. Select screwdrivers appropriate for given tasks.
Select screwdrivers for:
- slotted screw
- phillips (Frearson V, if applicable)
- clutch head
- allen
- briston

4.0203 Properly select a wrench for a given job:

a. Identify types:
- open end
- box end
- adjustable
- spanner
- pipe wrench
- socket wrench
- torque wrench

b. Demonstrate proper method of using wrenches:
- safety
- proper selection for job
- leverage
- checking nut tightness

UNIT 4.0 HAND TOOLS

TASK 4.02 PROPERLY USE HAND TOOLS FOR ASSEMBLY/DISASSEMBLY

---

PERFORMANCE ACTIONS (Con't.):

4.0204 Properly select and use pliers:

a. Identify major types of pliers.
b. Demonstrate proper use and care of pliers.

4.0205 Properly select and use wood working tools as required for installation:

a. Striking and struck tools.
b. Cutting tools.

PERFORMANCE STANDARDS:

- Properly identify, select, use, and care for hand tools used in assembly/disassembly HVAC work.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Standards for care of hand tools (See task 4.01).
- Safety.

UNIT 4.0 HAND TOOLS

TASK 4.03 USING HAND HACKSAW, CUT GIVEN MATERIAL IN REQUIRED TIME

---

PERFORMANCE OBJECTIVE:

Furnished with blueprint/drawing/specifications, and hand hacksaw; handsaw the metal in a given time to within 1/32 inch outside of scribed line.

PERFORMANCE ACTIONS:

4.0301 Review job requirements.

4.0302 Select hacksaw and blade.

4.0303 Properly mount blade in hacksaw frame.

4.0304 Secure piece to be sawed.

4.0305 Using correct technique saw workpiece to specifications:

a. Scribe or mark piece for cut.
b. Notch piece with file for start of cut.
c. Protect piece from damage.
d. Saw 1/32 inch outside of scribed or marked line.

PERFORMANCE STANDARDS:

- Using the hand hacksaw, cut given material, such as angle iron, in required time, within 1/32 inch outside of scribed or marked line, meeting instructor's standards for use and care of hacksaw.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify hand hacksaw parts, design.
- Identify types of materials which may be cut by hand hacksaw.
- Identify typical types of blades which may be used with hacksaw.
- Identify when and how to mount more than one blade on hacksaw.
- Describe/demonstrate proper technique in using hacksaw.
- Safety.
- Using the hacksaw for horizontal and vertical cuts.
- Selection of hacksaw blade: 32 teeth/in for ACR tubing recommended.

UNIT 4.0 HAND TOOLS

TASK 4.04 DRILL HOLES WITH PORTABLE DRILL

---

PERFORMANCE OBJECTIVE:

Given metal or wood to drill, specifications or instructions concerning drilling, locations already marked, and the necessary tools and equipment; drill the work as required to a tolerance of +/- 1/64 inch or specifications.

PERFORMANCE ACTIONS:

4.0401 Review specifications, instruction, or job drilling need.

4.0402 Locate and (if appropriate, center punch) work.

4.0403 Secure work.

4.0404 Select drill size.

4.0405 Select drill bit:

a. Check size as necessary.
b. Check sharpness.

4.0405 Mount drill bit in drill and properly tighten bit in chuck.

4.0406 Drill hole as needed:

a. Observe safety procedures.
b. Hold drill perpendicular to work.
c. Run drill at proper speed, if adjustable.
d. Reduce feed pressure as drill pentrates work.
e. Deburr hole as needed.

4.0407 Verify drilled hole is properly located and suitable for job.

4.0408 Clean/care for tools and return them to proper storage.

PERFORMANCE STANDARDS:

- Drill holes with portable drill as required to a tolerance of +/- 1/64 inch of requirements meeting instructor's standards for performance process and product.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Selection of drill bits.
- Selection of drill size for job.
- Alignment of drill/bit with work.
- Electrical safety in using portable power drill.

UNIT 4.0 HAND TOOLS

TASK 4.05 USE ADDITIONAL HAND TOOLS

---

PERFORMANCE OBJECTIVE:

Given tool box or access to additional tools such as wire brushes, feeler gages, files, fuse puller, crimpers, metal cutting/working snips and tools, pop riveter, and other tools; demonstrate proper method of identification, use, and care of these tools to the standards of the instructor.

(NOTE: Other hand tools, such as the tube cutter, may be taught in the later units.)

PERFORMANCE ACTIONS:

4.0501 Properly identify given additional hand tools; (Example)

- Wire brushes
- Feeler gages
- Files
- Fuse Puller
- Crimpers
- Metal working/cutting snips and tools
- Pop riveters
- other hand tools that may be selected by the instructor

4.0502 Demonstrate proper use of tools after orientation training.

4.0503 Demonstrate proper care of tools based on instruction and demonstration by teacher, returning tools to proper storage after use.

PERFORMANCE STANDARDS:

- Orientation training.
- Properly identified, use, and care for additional hand tools such as wire brushes, feeler gages, files, fuse puller, crimpers, metal working/cutting tools, and pop riveter to the standards of the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.

# UNIT 5.0

# HVAC BENCHWORK WITH HAND TOOLS

"For the purpose of this description, benchwork represents work placed on a bench or in a bench vise for operations usually involving hand tools.

Benchwork may be interpreted as including floor work using the same tools. The drill press and bench or pedestal grinder have been included since benchwork operations required of the electrician might involve those machines which are found in most training situations".

Benchwork operations typically are represented by the use of measuring instruments to layout work that is assembled/disassembled, sawed, drilled, filed, etc., as required.

See the previous unit, Hand Tools, for related training.

# HVAC
# HVAC BENCHWORK WITH HAND TOOLS
# SUGGESTED INSTRUCTION TIME

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 5.0 | HVAC BENCHWORK WITH HAND TOOLS | |
| 5.01 | Inspect Workbench Area for Safe Working Environment | * |
| 5.02 | Identify and Propely Use Bench Vise | * |
| 5.03 | Identify Types of Fasteners | * |
| 5.04 | Assemble and Fit Parts | * |
| 5.05 | Inspect, Clean, Lubricate Drill Press | * |
| 5.06 | Set Up a Drill Press | * |
| 5.07 | Drill Holes to Size | * |
| 5.08 | Inspect and Clean a Pedestal Grinder | * |
| 5.09 | Set-up Pedestal Grinder for Job | * |
| 5.10 | Bench File Workpiece | * |
| | TOTAL HOURS | 9 |

* - Total Time Estimated

# TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 5.0 | HVAC BENCHWORK WITH HAND TOOLS |
| 5.01 | (INSPECT WORKBENCH AREA FOR SAFE WORKING ENVIRONMENT) Using "performance actions" as a checklist, inspect the bench work area for safe working environment. All unsafe conditions must be reported immediately. All items must be marked safe or corrected to a safe condition. |
| 5.02 | (IDENTIFY AND PROPERLY USE A BENCH VISE) Given a standard bench vise demonstrate how to fasten the vise to the bench and use it properly. |
| 5.03 | (IDENTIFY TYPES OF FASTENERS) Given a random selection of typical fasteners the electrician may encounter, identify each fastener and its typical application. |
| 5.04 | (ASSEMBLE AND FIT PARTS) Given necessary tools and materials, necessary instruction, and parts to assemble and fit; assemble and fit parts as required to accomplish the assigned task. |
| 5.05 | (INSPECT, CLEAN, AND LUBRICATE DRILL PRESS) Given a drill press, operator's manual or instructions, cleaning materials, lubricants, and the necessary hand tools and materials; inspect, clean, and lubricate the drill press according to manufacturer's recommendations or instructor's standards. The drill press and surrounding area must be free of metal chips, excess lubricant, and foreign material. |
| 5.06 | (SET UP A DRILL PRESS) Given a drill press requiring set up for a drilling operation, an assortment of accessories and attachments, vise, V-block yoke and clamps, an assortment of drill bits and collets, and the necessary tools, equipment, and materials; set up the drill press for a drilling operation. All components must be mechanically secure with the drill bit fastened securely in the collet and the table set up for operation. |
| 5.07 | (DRILL HOLES TO SIZE) Given a drill press, workpiece, detail drawing, drilling specifications, and assortment of drill bits and tools, measuring instruments, and necessary materials; drill holes to specification with a tolerance of +/- 1/32 inches. |

5.08 (INSPECT AND CLEAN A PEDESTAL GRINDER) Given a operator's manual or equivalent, cleaning materials, and the necessary hand tools; inspect and clean a pedestal grinder according to manufacturer's recommended procedures. The grinder and surrounding area must be free of metal chips, excess lubricant, and foreign material.

5.09 (SET-UP PEDESTAL GRINDER FOR JOB) Given a pedestal grinder requiring set-up for a grinding operation, a grinding wheel requiring mounting, truing, and dressing, and operator's manual or equivalent, and the necessary tools, equipment, and materials; set-up the pedestal grinder and mount, true, and dress the grinding wheel for a grinding job. The grinding wheel must run true, and the grinding surface must not be loaded or glazed. The pedestal grinder must operate according to manufacturer's specifications.

5.10 (BENCH FILE WORKPIECE) Given a workpiece, blueprint or drawing/specifications, and necessary equipment; hand file the workpiece within a tolerance of +/- 1/16 inch on fractional dimensions or within blueprint specifications (+/- 1 degree on angular dimensions).

TASK 5.01 INSPECT WORKBENCH AREA FOR SAFE WORKING ENVIRONMENT

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PERFORMANCE OBJECTIVE:

Using "performance actions" as a checklist, inspect the bench work area for safe working environment. All unsafe conditions must be reported immediately. All items must be marked safe or corrected to a safe condition.

(OMIT ITEMS NOT APPLICABLE BY INDICATING "N/A".)

PERFORMANCE ACTIONS:

5.0101 Inspect machine tools in bench area:

a. Guards/safety devices in place.
b. Control location clear, safe.
c. Power transmission or drive mechanism safe.
d. Overload devices in place, proper value.
e. Ventilation, where applicable, provided.
f. Metal scraps cleaned up.
g. Attachments/accessories available.

5.0102 Hand tools:

a. Stored properly.
b. Not damaged.
c. Clean.
d. Safety devices, where applicable, provided/attached.

5.0103 Personal protection equipment: (Where applicable)

a. Foot wear (no canvas shoes, etc.).
b. Eye protection, when appropriate.
c. Head protection, where applicable.
d. First-aid station provided.
e. Fire extinguisher provided.

5.0104 Safety signs and markings displayed in proper locations and proper color coded markings used for safety.

5.0105 Floors, passageways, aisles, spaces around machines:

a. Clean.
b. Free of oil grease, or other liquids.

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PERFORMANCE ACTIONS (Con't.):

c. Materials not blocking work or passage area.
d. Non-skid mats or safety mats used where appropriate.

5.0106 Disposal cans:

a. Located in designated, convenient area.
b. Marked.
c. Covered, if applicable (for greasy, oily rags, etc.).

PERFORMANCE STANDARDS:

- Work bench area inspected for safety, using checklist provided.

SUGGESTED INSTRUCTION TIME:

## TASK 5.02 IDENTIFY AND PROPERLY USE A BENCH VISE

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PERFORMANCE OBJECTIVE:

Given a standard bench vise demonstrate how to fasten the vise to the bench and use it properly.

PERFORMANCE ACTIONS:

5.0201 Explain the purpose of the bench vise.

5.0202 Demonstrate proper techniques of using the bench vise.

PERFORMANCE STANDARDS:

- Properly identify and demonstrate how to use a standard bench vise to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

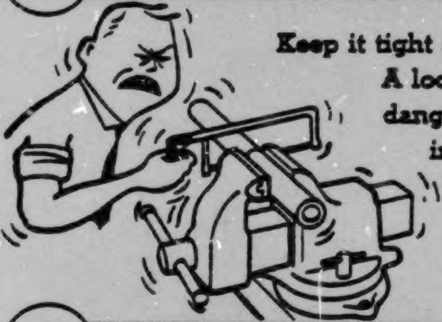
- Safety.

ADDENDUM PAGE ACCOMPANIES THIS TASK

Addendum To Task
5.02

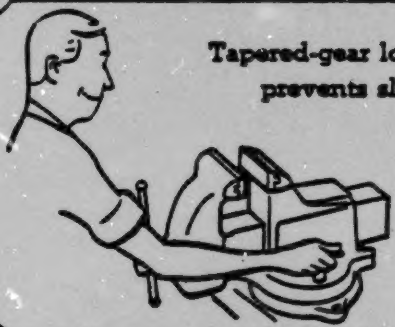
# COLUMBIAN
## Bench Vise Use and Care Chart

### 1 MOUNT VISE FIRMLY!



Keep it tight on bench. A loose vise is dangerous and inefficient.

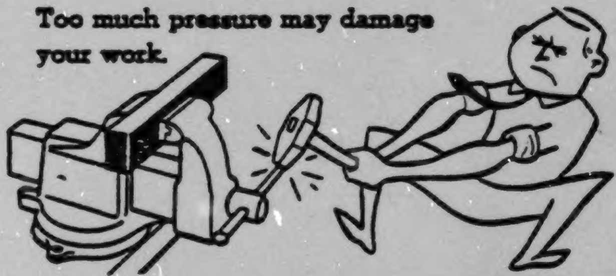
### 2 LOCK SWIVEL BASE SECURELY!



Tapered-gear lock bolt prevents slippage.

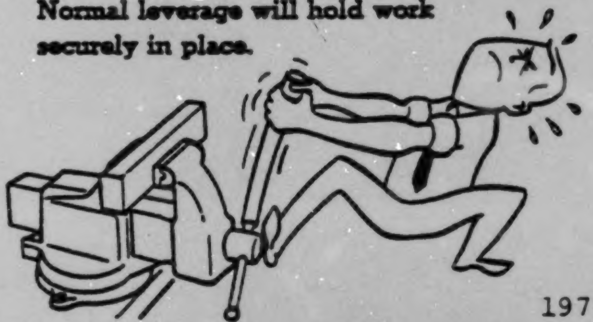
### 3 NEVER HAMMER THE HANDLE!

Too much pressure may damage your work.



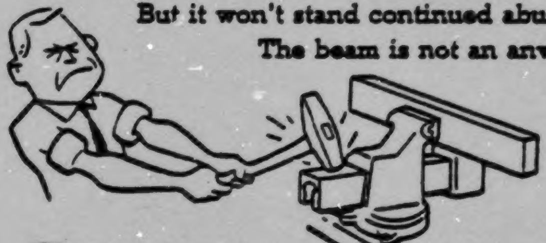
### 4 DON'T USE HANDLE EXTENSION!

Normal leverage will hold work securely in place.

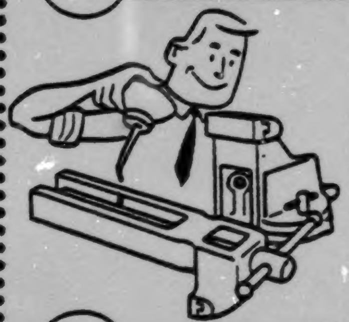


### 5 DON'T HAMMER THE BEAM!

Your vise will give almost unlimited use. But it won't stand continued abuse. The beam is not an anvil.

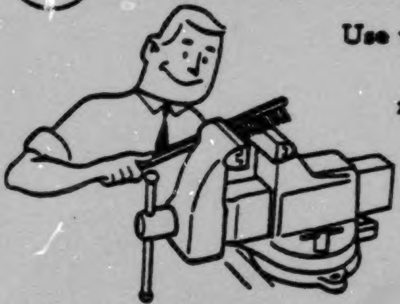


### 6 OIL THE SCREW!



Remove front jaw. Use oil or, preferably, light grease. Do this frequently. It will prevent screw wear.

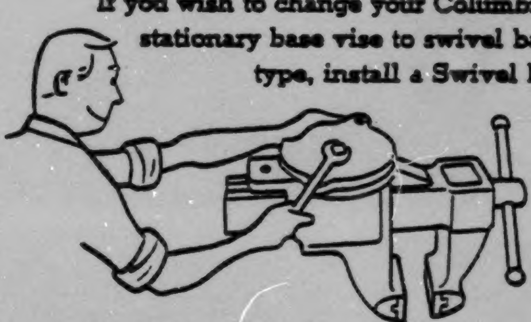
### 7 KEEP JAW FACES CLEAN!



Use wire brush or file card to remove chips and dust.

### 8 CONVERT TO SWIVEL BASE!

If you wish to change your Columbian stationary base vise to swivel base type, install a Swivel kit.



COLUMBIAN VISE DIVISION BEST COPY AVAILABLE

THE WARREN GROUP Hiram, Ohio 44234

UNIT 5.0 HVAC BENCHWORK WITH HAND TOOLS

TASK 5.03 IDENTIFY TYPES OF FASTENERS

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PERFORMANCE OBJECTIVE:

Given a random selection of typical fasteners the electrician may encounter, identify each fastener and its typical application.

PERFORMANCE ACTIONS:

5.0301 Identify fasteners:

a. Bolts.
b. Screws.
c. Nuts.
d. Studs.
e. Washers.
f. Internal threaded inserts.
g. Rivets.
h. Pins: Cotter, Dowel, Taper, Split dowel.
i. Retaining fasteners: Rings.
j. Keys: Square, Woodruff, Rocket, Taper.

5.0302 Identify some typical uses of fasteners.

PERFORMANCE STANDARDS:

- Identify types of fasteners common to electrical work and their typical uses to the standards of the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Commercial Supply Catalogs.

TASK 5.04 ASSEMBLE AND FIT PARTS

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PERFORMANCE OBJECTIVE:

Given necessary tools and materials, necessary instructions, and parts to assemble and fit; assemble and fit the parts as required to accomplish the assigned task.

PERFORMANCE ACTIONS:

5.0401 Assemble and fit parts as required.

PERFORMANCE STANDARDS:

- Assemble and fit parts to the instructor's standards.

(NOTE: Orientation training: Competency will be developed through practice and experience.)

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Tolerances.
- Types of fits:
    a. Loose
    b. Free
    c. Medium
    d. Snug
    e. Wringing
    f. Tight
    g. Heavy force and shrink

TASK 5.05 INSPECT, CLEAN, AND LUBRICATE DRILL PRESS

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PERFORMANCE OBJECTIVE:

Given a drill press, operator's manual or instructions, cleaning materials, lubricants, and the necessary hand tools and materials; inspect, clean, and lubricate the drill press according to manufacturer's recommendations or instructor's standards. The drill press and surrounding area must be free of metal chips, excess lubricant, and foreign material.

PERFORMANCE ACTIONS:

5.0501 Shut off power.

5.0502 Clean drill press:

a. Brush off all chips.
b. Wash grease and oil off machine surfaces.

5.0503 Lubricate drill press according to service manual or given instructions:

a. Coat column and table lightly with oil.
b. Apply grease to fittings.
c. Apply oil to oil cups.
d. Apply oil to sliding parts.

PERFORMANCE STANDARDS:

- Inspect, clean, and lubricate a drill press to given standards.
- The machine and surrounding area must be clean of chips, lubricant, and foreign material.
- The machine must operate properly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe procedures for inspecting and cleaning a drill press.
- Explain the necessary safety precautions.
- Identify materials used to clean a drill press.
- Explain reasons for performing routine inspection and cleaning of a drill press.
- Work holding devices:
  - Vise
  - C- Clamps
  - T-bolts, T-nuts
  - V-blocks
  - Clamps, Straps
- Safety.

TASK 5.06 SET UP A DRILL PRESS

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PERFORMANCE OBJECTIVE:

Given a drill press requiring set up for a drilling operation, an assortment of accessories and attachments, vise, V-block yoke and clamps, an assortment of drill bits and collets, and the necessary tools, equipment and materials; set up the drill press for a drilling operation. All components must be mechanically secure with the drill bit fastened securely in the collet and the table set up for operation.

PERFORMANCE ACTIONS:

5.0601 Clean drill press.

5.0602 Select proper drill or accessories.

5.0603 Adjust: table, head, and depth adjustments.

5.0604 If straight-shank drill is used, mount drill in drill chuck. (If taper-shank drill is used, insert it directly in spindle, or in a drill sleeve and then in spindle.)

5.0605 Turn on power to see if drill is running straight.

5.0606 Mount workpiece in holding device.

5.0607 Follow procedures to drill workpiece (see following task objectives).

PERFORMANCE STANDARDS:

- Set up a drill press for operation using given accessories and materials so that the drill press and components are mechanically secure and prepared for the required operation.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify: Variable speed control, head, motor, power feed, spindle, table, column, base and quill.
- Explain how to calculate speeds and feeds on a drill press.
- Identify attachments and accessories for the drill press.
- Identify sizes and capacities or various drill presses.
- Identify procedures for setting up a drill press.

RELATED TECHNICAL INFORMATION (Con't.):

- Explain how to mount a drill bit and collet in a drill press.
- Explain how to mount a vise and align a workpiece.
- Identify work hold devices available in the electricity shop or used in electrical work.
- Describe work holding procedures.
- Describe drill chucks and tool holding procedures.
- Identify safety considerations.

UNIT 5.0 HVAC BENCHWORK WITH HAND TOOLS

TASK 5.07 DRILL HOLES TO SIZE

---

PERFORMANCE OBJECTIVE:

Given a drill press, workpiece, detail drawing, drilling specifications, an assortment of drill bits and tools, measuring instruments, and necessary materials; drill holes in specification with a tolerance of +/- 1/32 inches.

PERFORMANCE ACTIONS:

5.0701 Assemble materials.

5.0702 Set up drill press.

5.0703 Select holding device and accessories.

5.0704 Secure work-holding device.

5.0705 Determine hole size.

5.0706 Align workpiece with center drill in chuck.

5.0707 Calculate speed.

5.0708 Set drill press speed.

5.0709 Center drill workpiece.

5.0719 Select and mount drill bit.

5.0711 Reset speed.

5.0712 Drill to specifications:

a. Use required lubricant.
b. Slow feed as drill penetrates workpiece.
c. Deburr hole.

5.0713 Measure drilled hole(s).

PERFORMANCE STANDARDS:

- Drill hole or holes to size in given workpiece with a tolerance of +/- 1/32 inch* or to specifications. (*or +/- cm.)

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Technique of easing up pressure as drill print breaks through work.
- Drilling techniques with thin metal.

*Tolerance standards will be determined by available measuring devices:

a. +/- 1/32 inch may be located between markings on 1/16 inch accuracy rule.
b. 1 cm. may be located on a typical metric rule, readily available.

TASK 5.08 INSPECT AND CLEAN A PEDESTAL GRINDER

---

PERFORMANCE OBJECTIVE:

Given an operator's manual or equivalent, cleaning materials, and the necessary hand tools; inspect and clean a pedestal grinder according to the manufacturer's recommended procedures. The grinder and surrounding area must be free of metal chips, excess lubricant, and foreign material.

PERFORMANCE ACTIONS:

5.0801 Review instructions.

5.0802 Assemble cleaning materials.

5.0803 Inspect and clean the pedestal grinder following outlined procedures.

5.0804 Inspect the pedestal grinder for cleanliness and safety.

5.0805 Clean around the pedestal grinder as appropriate.

PERFORMANCE STANDARDS:

- Inspect and clean a pedestal grinder according to manufacturer's recommended procedures and clean surrounding area as appropriate.
- Process performance must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Identify proper materials used to clean a pedestal grinder.

UNIT 5.0 HVAC BENCHWORK WITH HAND TOOLS

TASK 5.09 SET-UP PEDESTAL GRINDER FOR JOB

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PERFORMANCE OBJECTIVE:

Given a pedestal grinder requiring set-up for a grinding operation, a grinding wheel requiring mounting, truing, and dressing, an operator's manual or equivalent, and the necessary tools, equipment, and materials; set-up the pedestal grinder and mount, true, and dress the grinding wheel for a grinding job. The grinding wheel must run true, and the grinding surface must not be loaded or glazed. The pedestal grinder must operate according to manufacturer's specifications.

PERFORMANCE ACTIONS:

5.0901 Review manufacturer's instruction manual or equivalent.

5.0902 Assemble required materials, tools, and equipment.

5.0903 Select proper grinding wheel for job.

5.0904 Inspect and ring-test grinding wheel prior to mounting.

5.0905 Mount, true, and dress grinding wheel.

5.0906 Set-up pedestal grinder for required operation.

5.0907 Operate pedestal grinder in a safe and proper manner.

5.0908 Perform grinding operation to specifications.

PERFORMANCE STANDARDS:

- Set-up pedestal grinder according to instruction given; mount, true, and dress wheel; and demonstrate proper use of pedestal grinder.
- The grinding wheel must run true, and the grinding surface must not be loaded or glazed.
- The pedestal grinder must operate according to manufacturer's specifications.
- Process performance must be instructor's standards.

SUGGESTED INSTRUCTION TIME:

UNIT 5.0 HVAC BENCHWORK WITH HAND TOOLS

TASK 5.09 SET-UP PEDESTAL GRINDER
(Con't.)

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RELATED TECHNICAL INFORMATION:

- Identify:
  - a. Pedestal
  - b. Motor
  - c. Grinding wheel
  - d. Safety shield
  - e. Tool rest
  - f. Wheel guard
  - g. Coolant reservoir
  - h. Power switch
- Identify grinding wheel defects.
- Selection of proper grinding wheel for job.
- Procedures for setting up pedestal grinder demonstrated by instructor.
- Basic uses of pedestal grinder.
- Selection of coolant used for wet grinding.
- Proper use of tool rest and wheel guard.
- Safety with the pedestal grinder.
  - "Don't stand in front of grinding wheel: Stand to one side for about a minute as wheel is turned on in case wheel disintegrates."

TASK 5.10 BENCH FILE WORKPIECE

---

PERFORMANCE OBJECTIVE:

Given a workpiece, blueprint or drawing/specifications, and necessary equipment; hand file the workpiece within a tolerance of +/- 1/16 inch on fractional dimensions or within blueprint specifications (+/- 1 degree on angular dimensions).

PERFORMANCE ACTIONS:

5.1001 Review specifications.

5.1002 Select proper file.

5.1003 Check file handle or install handle on file.

5.1004 Clean file, if necessary (file should have been cleaned prior to storage in tool room/box).

5.1005 Mount workpiece.

5.1006 Test flatness or angle of work.

5.1007 Check for pinning (condition of file) and chalk file.

5.1008 File to final tolerance:

a. Avoid allowing file to rock or see-saw, which might produce a crowned surface.
b. Use flat filing or drawfiling techniques as appropriate.

5.1009 Upon completion of job task, clean file and return it to tool room/box.

PERFORMANCE STANDARDS:

- Hand file workpiece within a tolerance of +/- 1/16 inch on fractional dimensions (+/- 1 degree on angular dimensions) or within blueprint specifications.
- File should be held in a safe manner, flat so it does not rock or see-saw, and used in a procedure recommended by the instructor.
- Performance process and product must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- File patterns, cuts of files: Single, double, rasp, and curved.
- Straightforward, flat, draw, and round-corner filing.
- Use of the file card and care of files.
- Safety with files.
- Techniques of hand filing: Instructor's standards.
- Measuring instruments.
- Use of bench vise.

# POWER TOOLS OMITTED FROM GUIDE

The following power tools have been omitted from this articulated guide, at this time, because all of the secondary programs do not have this equipment or do not include instruction on this equipment as a part of the regular secondary program.

- -Circular Saw
- -Reciprocating Saw
- -Sabre Saw
- -Power Hacksaw

# UNIT 6.0

# SPECIAL HVAC TOOLS AND EQUIPMENT

# HVAC
## HVAC SPECIAL TOOLS
## SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 6.0 | HVAC SPECIAL TOOLS | |
| 6.01 | Use the Gauge Manifold (Refrigeration Gauge Set) | * |
| 6.02 | Use Propane or Prestolite Gas Cylinder | * |
| 6.03 | Use Halide Leak Detector | * |
| 6.04 | Use Fin Combs | * |
| 6.05 | (OPTIONAL) Use the Mercury U-tube Manometer | * |
| 6.06 | Dial-a-Charging Cylinder | * |
| 6.07 | Demonstrate Proper Use of and Care of Vacuum Pump | * |
| 6.08 | Demonstrate Proper Use of Low Side Liquid Charger | * |
| 6.09 | (OPTIONAL) Use Acid Test Kit | * |
| 6.10 | Use Thermometer to Measure Temperature | * |
| 6.11 | Demostrate Proper Use of Sling Psychrometer | * |
| 6.12 | (OREINTATION/OPTIONAL) Use the Inclined Manometer | * |
| | TOTAL HOURS | 45 |

* - Total Time Estimated

## TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 6.0 | HVAC SPECIAL TOOLS |
| 6.01 | (USE THE GAUGE MANIFOLD [REFRIGERATION GAUGE SET]) Given refrigeration gauge set, instruction in using gauge set, and system requiring check of refrigerant pressures; analyze the condition of the system. |
| 6.02 | (USE PROPANE OR PRESTOLITE GAS CYLINDER) Given proper instruction and safety orientation, propane or prestolite gas cylinder with torch attachment, striker, and other materials needed; demonstrate proper method of setting-up the propane or prestolite gas cylinder for HVAC work, cut on and ignite the gas with striker, and adjust the gas for desired flame. Performance must be to the instructor's standards. Observe safety procedures. |
| 6.03 | (USE HALIDE LEAK DETECTOR) Given a Halide Leak Detector, propane or prestolite gas cylinder, and striker, proper instruction, and necessary tools and materials, a system to check for leaks in refrigerant circuit; demonstrate proper use of Halide Leak Detector. |
| 6.04 | (USE FIN COMBS) Use fin combs provdied to maintain and restore damaged fin tube surfaces on a given system so that an unrestricted air flow results. |
| 6.05 | (USE THE MERCURY U-TUBE MANOMETER) Given instruction, the Mercury U-tube Manometer, and all necessary materials as well as a system to check for evaporation; read the vacuum as required. Use of the Mercury U-tube Manometer must be according to instruction given and the manufacturer's procedures. |
| 6.06 | (DIAL-A-CHARGING CYLINDER) Given instruction, the Dial-a-charging cylinder, a situation requiring a specific refrigerant by weight; demonstrate proper orientation use of the Dial-a-charging Cylinder. |
| 6.07 | (DEMOSTRATE PROPER USE AND CARE OF VACUUM PUMP) Given instruction, and electrically operated vacuum pump, and the necessary accessories, tools, and materials; pull a high vacuum on a given air conditioning or refrigeration system. |

6.08 (DEMONSTRATE PROPER USE OF LOW SIDE LIQUID CHARGER) Given a Low Side Liquid Charger, proper instructions, and all necessary tools and materials; demonstrate proper use of the low side liquid charger to charge a system with liquid refrigerant quickly and safely.

6.09 (USE ACID TEST KIT) Using an acid test kit, such as the Sporlan AK-1 (disposable) or another kit, following instructions given, and given all necessary tools and materials; check oil from reciprocating type refrieration compressor which is suspected of acid contamination because of burnout or moisture in system.

6.10 (USE THERMOMETER TO MEASURE TEMPERATURE) Given a glass stem or dial stem thermometer, instructions, and necessary materials; measure temperature as required within +/- 1/2 degree. Findings must agree with instructor's and proper techniques of measuring must be demonstrated.

6.11 (DEMOSTRATE PROPER USE OF SLING PSYCHROMETER) Determine dry bulb and wet bulb temperatures for comparison to determine percent of relative humidity of a given environment using the sling psychrometer provided and following instruction given. A table/chart may be provided by the instructor to assist in determining the percent of relative humidity.

6.12 (USE THE INCLINED MANOMETER) Given instruction, an inclined manometer, and all necessary materials; measure the static pressure in a duct (or the static pressure differential across a coil), in hundredths of an inch of water column.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.01 USE THE GAGE MANIFOLD (REFRIGERATION GAGE SET)

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PERFORMANCE OBJECTIVE:

Given refrigeration gage set, instruction in using gage set, and system requiring check of refrigerant pressures; use the gauge set to analyze the condition of the system.

PERFORMANCE ACTIONS:

6.0101 Identify:

a. Hand valve for compound pressure gage.
b. High pressure gage.
c. Suction service valve hose.
d. Discharge service valve hose.
e. Vacuum pump or refrigerant cylinder hose.

6.0102 Connect Compound Gage to low side (suction line) of system.

6.0103 Connect High Pressure Gage to high side of system.

a. Read Compound Gage pressure and temperature (F). Note "O" = 14.7 psi atmospheric pressure @ sea level. Pressure above "O" is measured in psi. Pressure below "O" (vacuum) is measured in inches of mercury with 30 inches being the lowest measure possible.
b. Read High Pressure Gage (and temperature). Read between "O" and 500 psi.

6.0104 Note different positions of gages' manifold valves for various readouts and operations:

a. Gage reading.
b. Bypassing.
c. Charging refrigerant or adding oil.
d. Purging or removing refrigerant.

PERFORMANCE STANDARDS:

- Use the Refrigeration Gage Set to analyze the condition of a given refrigeration system.
- Demonstrate proper use of gages for different readouts and operations.
- Performance process must be to instructor's standards.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.01 USE THE GAGE MANIFOLD (REFRIGERATION GAGE SET) (Con't.)

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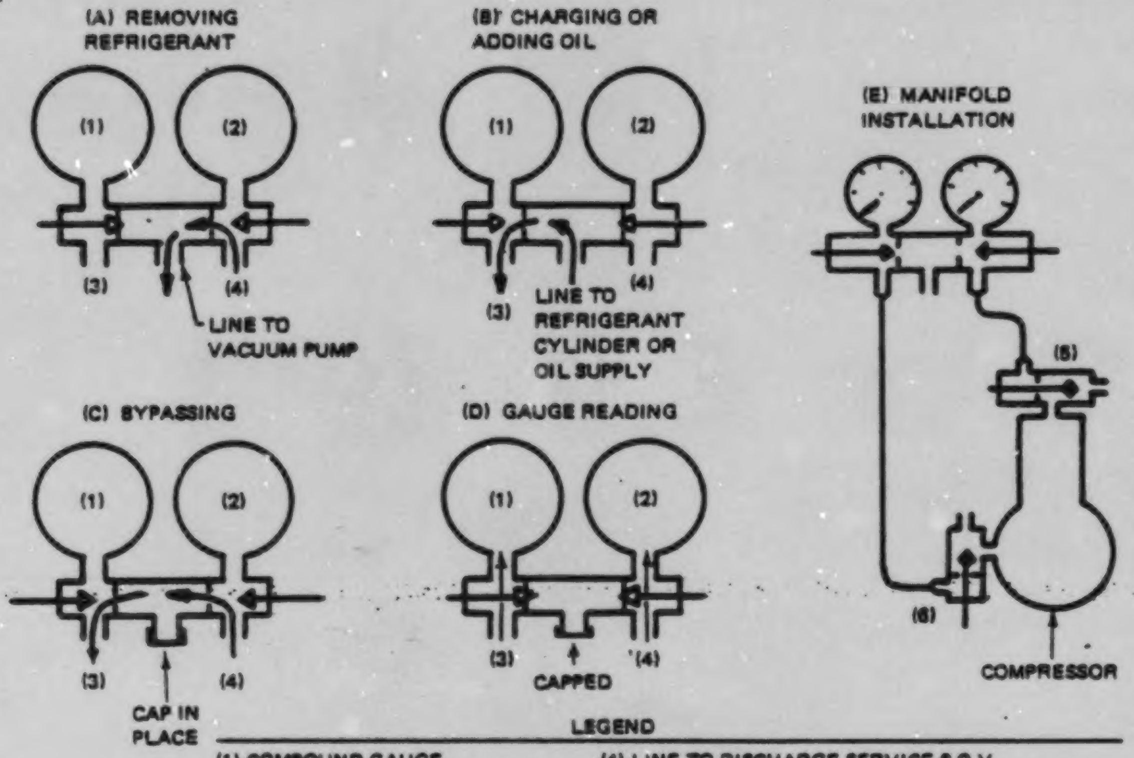
SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Safety:
  - Wear safety goggles
  - Avoid refrigerant burns
  - Use caution in working with pressures: Use appropriate hoses
- Maintenance:
  - Keep hoses dry and clean
  - Prevent oil from entering gages
  - Avoid excessive tightening of hand valves (which may wear valve seats)
  - Replace stem seals and valve seats when appropriate
  - Following demonstrated instruction, calibrate gages necessary, according to instruction given and manufacturer's recommendations
- Inspect hoses regularly for cracks and wear and replace them prior to failure.

ILLUSTRATION OF MINIMUM OPERATIONS FOR COMPETENCY (See next page).


(A) REMOVING REFRIGERANT
(1)
(2)
(3)
(4)
LINE TO VACUUM PUMP
(B) CHARGING OR ADDING OIL
(1)
(2)
(3)
(4)
LINE TO REFRIGERANT CYLINDER OR OIL SUPPLY
(E) MANIFOLD INSTALLATION
(5)
(6)
COMPRESSOR
(C) BYPASSING
(1)
(2)
(3)
(4)
CAP IN PLACE
(D) GAUGE READING
(1)
(2)
(3)
(4)
CAPPED

LEGEND

(1)-COMPOUND GAUGE
(2)-HIGH PRESSURE GAUGE
(3)-LINE TO SUCTION SERVICE S.O.V.
(4)-LINE TO DISCHARGE SERVICE S.O.V.
(5)-BACK-SEAT PORT OF DISCHARGE SERVICE S.O.V.
(6)-BACK-SEAT PORT OF SUCTION SERVICE S.O.V.

DATA TABLE

| | |
|---|---|
| Type of Manifold used | |
| Name of compound gage | |
| Size of dial | |
| Type of fitting | |
| Scale reading | |
| Name of pressure gage | |
| Size of dial | |
| Type of fitting | |
| Scale reading | |
| Comments | |

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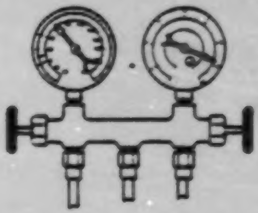
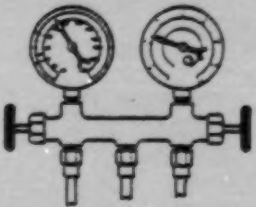
## ABNORMAL REFRIGERANT PRESSURE

### HIGH HEAD PRESSURE



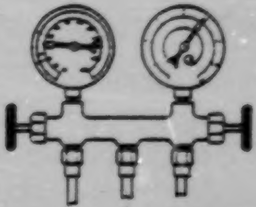
1 - Air or non-condensables in the system.
2 - Defective condenser fan motor.
3 - Obstructions in the condenser such as leaves, dirt, etc.
4 - Over charge of refrigerant.
5 - Recirculation of condenser air.
6 - Higher than ambient temperature air entering condenser.
7 - Wrong rotation of condenser fan blade.

### LOW HEAD PRESSURE



1 - Low refrigerant charge.
2 - Out on internal pressure relief.
3 - Defective compressor valves.
4 - Low ambient temperature.

### LOW SUCTION PRESSURE



1 - Loose or broken evaporator blower belt.
2 - Defective or over loaded evaporator blower motor.
3 - Obstructed or dirty evaporator.
4 - Dirty air filters.
5 - Low refrigerant charge.
6 - Dirty or faulty expansion valve (leaking around push rod).
7 - Recirculation of evaporator air (compare return air temperature with conditioned space temperature).
8 - Restriction in refrigerant system.
9 - Restricted or undersized duct work.
10 - Wrong rotation of evaporator blower.

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UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.02 USE PROPANE OR PRESTOLITE GAS CYLINDER

---

PERFORMANCE OBJECTIVE:

Given proper instruction and safety orientation, propane or prestolite gas cylinder with torch attachment, striker, and other materials needed; demonstrate proper method of setting-up the propane or prestolite gas cylinder for HVAC work, cut on and ignite the gas with a striker, and adjust the gas for the desired flame. Performance must be to the instructor's standards. Observe safety procedures.

PERFORMANCE ACTIONS: (TO BE OUTLINED BY THE INSTRUCTOR.)

6.0201 Observe proper techniques in setting up the propane or prestolite gas cylinder.

6.0202 Demostrate proper method of cutting gas on and using striker to ignite gas.

6.0203 Properly adjust gas flame.

PERFORMANCE STANDARDS:

- Demonstrate the proper method of setting up the propane or prestolite gas cylinder, igniting the gas and properly adjusting the flame, and correctly using the torch in HVAC work. Performance must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Identification of propane and prestolite gas.
- Use of striker in igniting gas.

TASK 6.03 USE HALIDE LEAK DETECTOR

---

PERFORMANCE OBJECTIVE:

Given a Halide Leak Detector, propane or prestolite gas cylinder, and striker, proper instruction, and necessary tools and materials, a system to check for leaks in refrigerant circuit; demonstrate proper use of Halide Leak Detector.

PERFORMANCE ACTIONS:

6.0301 Assemble materials.

6.0302 Attach detector to gas cylinder so there is no leak.

6.0303 Light Detector: Adjust flame to minimum level until reactor glows.

a. Manipulate search hose to detect possible leaks.
b. Observe for bluish-green color flame as leaking refrigerant gas comes into contact with flame reactor plate.

PERFORMANCE STANDARDS:

- Use Halide Leak Detector on given refrigerant circuit to determine leaks in system.
- Detector must be set up and operated properly.
- Leaking refrigerant gas must be detected by a change in flame color.
- Performance must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety:
  - Storage of detector with attached gas bottle
  - Connection of gas bottle to detector
  - Inspection of test hose condition
  - Precaution in not breathing toxic by-products of burning refrigerant, such as Phosgene, a poison gas
  - Use and care of open flame
  - Soap bubbles last
  - Colors produced by flame in contact with refrigerant

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.04 USED FIN COMBS

---

PERFORMANCE OBJECTIVE:

Use fin combs provided to maintain and restore damaged fin tube surfaces on a given system so that an unrestricted air flow results.

PERFORMANCE ACTIONS:

6.0401 Select proper Fin Comb(s).

6.0402 Place fin bomb between aluminum fins of coil surface and move it parallel with fins to straighten and separate bent fins.

PERFORMANCE STANDARDS:

- Using proper size fin combs, straighten bent fins of coil surface so they are parallel and do not restrict air flow.
- Performance technique must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety: Care in working with sharp coil surfaces.
- Maintain clean fin combs with no damaged parts.

TASK 6.05 (Optional) USE THE MERCURY U-TUBE MANOMETER

---

PERFORMANCE OBJECTIVE:

Given instruction, the Mercury U-Tube Manometer, and all necessary materials as well as a system to check for evaporation; read the vacuum as required. Use of the Mercury U-Tube Manometer must be according to instructions given and the manufacturer's procedures.

PERFORMANCE ACTIONS:

6.0501 Assemble gage, materials, and review instruction book.

6.0502 Set up gage and calibrate:

a. Remove gage head, spring and washer.
b. Grip extended threaded portion of plumber.
c. Back off nut at upper end about 1/4 inch with wrench supplied.
d. Remove plunger sealing mechanism slowly, not removing any mercury.
e. Reassemble gage head, vacuum tight, and mount in vertical position.
f. Connect directly to vacuum pump using vacuum tight line and fittings.
g. Create a vacuum high enough to cause two legs of mercury to obtain same level.
h. Loosen upper and lower thumb screws that hold gage scale to frame.
i. Slide scale up or down until "O" reference mark is same level as two legs of mercury and tighten screws.
j. Gage is now tested for accuracy and is ready to give reliable readings.

6.0503 Make required readings.

PERFORMANCE STANDARDS:

- Use the Mercury U-Tube Manometer to read the vacuum of a given system to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Care in use of Mercury U-Tube Manometer.
- Calibration of instrument.
- Proper storage of the manometer.
- Alternate tool: Micron Gage

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.06 DIAL-A-CHARGING CYLINDER

---

PERFORMANCE OBJECTIVE:

Given instruction, the Dial-A-Charging Cylinder, a situation requiring a specific refrigerant by weight; demonstrate proper orientation use of the Dial-A-Charging Cylinder.

PERFORMANCE ACTIONS:

6.0601 Assemble instrument and materials.

6.0602 Connect charging hose from valve at bottom of charging cylinder to valve on refrigerant tank. Insert refrigerant tank so valve end is down.

6.0603 To fill cylinder with refrigerant, open valves on charging cylinder and refrigerant tank. Open valve on top of cylinder to bleed vapor from cylinder and speed operation.

6.0604 When liquid refrigerant is visible in sight glass, shut off valve on cylinder and dial plastic shroud to point where pressure heading for refrigerant being used is over sight glass and corresponds to pressure shown on gage on top of cylinder.

6.0605 Open valve on cylinder and fill to desired amount. (Do not fill cylinder with more than maximum calibration for refrigerant being used at pressure reading on dial corresponding to gage pressure.)

6.0606 When cylinder is filled to desired amount, shut off both valves on cylinder and valve on refrigerant tank.

6.0607 Disconnect charging hose from refrigerant tank. (Being sure to avoid contact with refrigerant.)

6.0608 When ready to charge refrigerant system, connect hose from cylinder to system. Dial plastic shroud on cylinder to point where pressure reading for refrigerant being used is over sight glass tube and corresponds with gage pressure on cylinder.

PERFORMANCE ACTIONS (Con't.):

6.0609 Open valve on bottom of cylinder and charge with factory specified amount. (Charging in high side with liquid.) (If charged w/vapor out of top of cylinder, and if necessary to get more refrigerant into system where pressure is about equal, heat cylinder.)

PERFORMANCE STANDARDS:

- Demonstrate proper procedures in using the Dial-A-Charging Cylinder to place a given refrigerant by weight in a given system.
- Instructor's standards for performance process must be met.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Care in use of valves, cylinder, and refrigerant tank.
- Proper procedures for heating cylinder demonstrated by instructor.
- Proper operation of cylinder demonstrate by instructor.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.07 DEMONSTRATE PROPER USE AND CARE OF VACUUM PUMP

---

## PERFORMANCE OBJECTIVE:

Given instruction, an electrically operated vacuum pump, and the necessary accessories, tools, and materials; pull a high vacuum on a given air conditioning or refrigeration system.

## PERFORMANCE ACTIONS:

6.0701 Assemble vacuum pump and accessories, tools, and materials.

6.0702 Check reference information as required.

6.0703 Attach evacuation hose (to intake port), turn pump on, open any valves between pump and unit being evacuated, and measure level of vacuum. Operate gas ballast valve according to instructions, turning the valve counterclockwise to open it and help evacuate the system.*

(NOTE: Pump can attain ultimate vacuum only with gas ballast valve off.)

6.0704 If hoses are used, valve off system to hold vacuum, preferebly using diaphragm valves instead of ordinary manifold gage set (for positive seal to isolate high vacuum).*

6.0705 When proper vacuum has been obtained close valves and turn pump off. Disconnect tubing hose from intake port.

6.0706 Connect hose to refrigerant drum, open drum evacuation hose (purge), open both gages bring system up to atmospheric pressure.

## PERFORMANCE STANDARDS:

- Demonstrate proper set up and procedures for connecting a vacuum pump to a given system and drawing a high vacuum.
- Proper operation and care of the pump must be demonstrated and must be according to manufacturer's recommendations or instructor's standards.

## SUGGESTED INSTRUCTION TIME:

| | | |
|---|---|---|
| UNIT | 6.0 | HVAC SPECIAL TOOLS |
| TASK | 6.07 | DEMONSTRATE PROPER USE AND CARE OF VACUUM PUMP (Con't.) |

---

RELATED TECHNICAL INFORMATION:

- Safety: Observing grounding and belt guard.
- Proper set up of pump for pulling high vacuum.
- Use of tubing verses hose and how in size and length of hose influence time of evacuation.
- Maintenance of pump: Adding oil.
- Changing oil.
- Flushing the pump.

*When evacuating, open pump to high side if system is open, compound gauge will start moving into vacuum. At that point, open low side and evacuate from both sides.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.08 DEMONSTRATE PROPER USE OF LOW SIDE LIQUID CHARGER

---

PERFORMANCE OBJECTIVE:

Given a Low Side Liquid Charger, proper instructions, and all necessary tools and materials; demonstrate proper use of the Low Side Liquid Charger to charge a system with liquid refrigerant quickly and safely.

PERFORMANCE ACTIONS:

6.0801 Assemble charger and materials to be used.

6.0802 Place charging device on suction gage port. Attach charging hose to charging device so that liquid refrigerant may be charged through it with no danger to the compressor due to slugging. (Liquid is metered through an orifice with the liquid charger and is in vapor form when entering unit.)

(NOTE: Liquid charger is equipped with an internal check valve which opens for drawing an unrestricted vacuum.)

PERFORMANCE STANDARDS:

- Demonstrate proper use of Low Side Liquid Charger to charge a system with liquid refrigerant quickly and safely.
- Performance process must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety in working with liquid refrigerant.
- Cap both ends of charger when not in use to keep it clean.
- Theory and application of charger.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.09 (Optional) USE ACID TEST KIT

---

PERFORMANCE OBJECTIVE:

Using an Acid Test Kit, such as the Sporlan AK-1 (disposable) or another kit, following instructions given, and given all necessary tools or materials; check oil from reciprocating type refrigeration compressor which is suspected of acid contamination because of burnout or moisture in system.

PERFORMANCE ACTIONS:

6.0901 Assemble Acid Test Kit.

6.0902 Mix solutions according to instructions.

6.0903 Collect oil to be tested.

6.0904 Mix oil and test liquid and observe for satisfactory/unsatisfactory color.

(NOTE: For centrifugal systems: Use the Acid Test Kit to test Refrigerant 11 or 113.)

PERFORMANCE STANDARDS:

- Demonstrate proper techniques in the use of the Acid Test Kit to check the oil from a reciprocating type refrigeration compressor as satisfactory or unsatisfactory.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Proper handling of test solutions to avoid dangerous vapor or contamination with skin.
- Care and storage of test solutions.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.10 USE THERMOMETER TO MEASURE TEMPERATURE

---

PERFORMANCE OBJECTIVE:

Given a glass stem or dial stem thermometer, instructions, and necessary materials; measure temperature as required within +/- 1/2 degree. Findings must agree with instructors and proper techniques of measuring must be demonstrated.

PERFORMANCE ACTIONS:

6.1001 Assemble:

a. Glass Stem Thermometer.
b. Dial Stem Thermometer.

6.1002 Insert stem of thermometer into airstream or substance being measured.

6.1003 Read temperature on scale.

6.1004 Upon collecting reading, store thermometer properly.

PERFORMANCE STANDARDS:

- Use the glass or dial stem thermometer to make temperature measurements of given situations +/- 1/2 degree of readings found by the instructor.
- Performance process must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Techniques of using the glass stem and dial stem thermometers.
- Care of thermometers: No exposing them to temperatures off scale, etc.

EXPANDED:

- Dial type thermometer with remote temperature bulb.
- Dial thermometers for heat applications.
- Maximum-minimum thermometers.
- Check calibration of thermometer by using ice and water to establish 32 degrees F.
- If instrument can be calibrated, calibrate by manufacturer's instructions.

| | | |
|---|---|---|
| UNIT | 6.0 | HVAC SPECIAL TOOLS |
| TASK | 6.11 | DEMONSTRATE PROPER USE OF SLING PSYCHROMETER |

---

PERFORMANCE OBJECTIVE:

Determine dry bulb and wet bulb temperatures for comparison to determine percent of relatively humidity of a given environment using the sling psychrometer provided and following instructions given. A table/chart may be provided by the instructor to assist in determining the percent of relatively humidity.

PERFORMANCE ACTIONS:

6.1101 Assemble sling psychrometer.

6.1102 Saturate the wick with water, tighten cap to prevent leakage.

6.1103 Pull tube clear of body so body can swivel.

6.1104 Holding tube, whirl body several revolutions per second.

6.1105 Continue whirling until temperature stabilizes (about 1.5 minutes). Until mercury stops moving, then swing one more time.

a. Read wet bulb thermometer.
b. Read dry bulb thermometer.

6.1106 Set wet and dry bulb temperatures opposite each other on slide rule calculator scales.

6.1107 Read percent of relatively humidity (%RH) on remaining scale.

(NOTE 1: Wet bulb reading must be taken as quickly as possible for maximum accuracy.)

(NOTE 2: For precise work, use psychometric chart or tables.)

PERFORMANCE STANDARDS:

- Demonstrate proper use of sling psychrometer to make wet and dry temperature readings and calculate the percent of relatively humidity in a given environment.
- Use a psychometric chart or tables as supplied by the instructor, if required.

TASK 6.11 DEMONSTRATE PROPER USE OF SLING PSYCHROMETER

---

PERFORMANCE STANDARDS (Con't.):

- Performance process must be to the instructor's standards and readings must agree with the instructor's (or predetermined readings.)

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Care of sling psychrometer.
- Reading psychometric chart/tables.
- Factors which may influence the accuracy of readings.

UNIT 6.0 HVAC SPECIAL TOOLS

TASK 6.12 (Orientation/ Optional*) USE THE INCLINED MANOMETER

---

PERFORMANCE OBJECTIVE:

Given instruction, an Inclined Manometer, and all necessary materials; measure the static pressure in a duct (or the static pressure differential across a coil), in hundredths of an inch of water column.

PERFORMANCE ACTIONS:

6.1201 Assemble inclined manometer.

6.1202 Open both valves on top of instrument at least 1 turn.

6.1203 Place instrument of flat surface and adjust leg so that instrument is level, or attached instrument to a vertical metal surface with magnets and adjust until level.

6.1204 Slide scale to "zero" mark so it is in line with top of oil column.

6.1205 Attach one end of each hose to each of the two valves on top of the instrument.

6.1206 Pressure Differential Reading:

a. Connect other end of left hand hose to duct on upstream or high pressure side of coil.
b. Connect end of the right hand hose to duct on the downstream side of coil.

6.1207 Comparison of Static Pressure with a Duct to Atmospheric Pressure:

a. [illegible] connection to left side of instrument for positive (above atmospheric) pressures.
b. Connect to right side of instrument for negative (below atmospheric) pressures.

6.1208 Take reading on scale in line with oil meniscus.

6.1209 When finished, remove hoses, close valves to avoid fluid loss, and return to carrying case, and proper storage.

TASK 6.12 (Orientation/ Optional*) USE THE INCLINED MANOMETER (Con't.)

---

PERFORMANCE STANDARDS:

- Use the inclined manometer to measure the static pressure in a duct or the static pressure differential across a coil.
- Performance process must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Care of instrument.
- Replinishment of oil (red draft gage oil, specific gravity of 0.826).

*If available/servicable.

# UNIT 7.0

# HVAC TEST INSTRUMENTS

# STANDARDS

Standards for this module are based on the following publications:

Proper Use and Care of Hand Tools, Pliers, Screwdrivers, Wrenches, Striking & Struck Tools, Chicago, IL: Klein Tools, Inc., 1977.

Test Instruments and Tools Used in HVAC Servicing and Troubleshooting. Dallas, TX: Lennox Industries Inc. (Education Dept.), ca. 1980.

Althouse, Andrew D.; Turnquist, Carl H.; and Bracciano, Alfred F. Modern Refrigeration and Air Conditioning. South Holland, IL: The Goodheart-Willcox Company, Inc., 1982.

Lang, V. Paul. Air Conditions: Procedures and Installation. Albany, NY: Delmar Publishers Inc., 1982.

Miller, Rex. Refrigeration and Air Conditioning Technology. Peoria, IL: Bennett Publishing Company, 1983.

Wantiez, Gary W. Air Conditioning and Refrigeration, Book One. Stillwater, OK: Mid-American Vocational Curriculum Consortium, 1977.

Other sources of standards might be substituted or might be more applicable. These sources, however, were available and appeared to represent most of the hand tools, special tools and equipment, and test instruments used by the HVAC mechanic.

In addition, outcome-referenced tests may use visuals provided by manufacturers of some of the latest types of special tools or test instruments.

# HVAC
# HVAC TEST INSTRUMENTS
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | | SUGGESTED HOURS |
|---|---|---|---|
| Unit | 7.0 | HVAC TEST INSTRUMENTS | |
| | 7.01 | Use Capacitor Analyzer | * |
| | 7.02 | Use the Hermetic Analyzer | * |
| | 7.03 | (ORIENTATION) Use Electronic Leak Dectector | * |
| | 7.04 | Thermistor Vacuum Gauge | * |
| | 7.05 | Use Electronic Temperature | * |
| | 7.06 | Use Millivolt Meter for Measurements of Small Voltages | * |
| | 7.07 | Use the Volt-ohm-meter (VOM) | * |
| | 7.08 | Use the Clamp-on Ammeter | * |
| | | TOTAL HOURS | 45 |

* - Total Time Estimated

## TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 7.0 | HVAC TEST INSTRUMENTS |
| 7.01 | (USE CAPACITOR ANALYZER) Given a capacitor analyzer, capacitors or circuits to test, and instruction; check capacitors for leakage to the standards of the instructor. Emphasis will be on orientation to the use of the capacitor analyzer. |
| 7.02 | (USE THE HERMETIC ANALYZER) Given a hermetic analyzer, such as the "ANNIE" by Mechanical Refrigeration Enterprises, a compressor (stuck compressor) and required tools, equipment, and power sources; for orientation, use the hermetic analyzer to rock free a stuck compressor and to determine a faulty circuitry or components. Also, temporarily rely on analyzer to support a refrigeration system, while replacement parts are being obtained. |
| 7.03 | (USE ELECTRONIC LEAK DETECTOR) Given an electronic halogen leak detector, power source, refrigerant system to check for leaks, and necessary instruction, tools and materials; check for leaks. |
| 7.04 | (THERMISTOR VACUUM GAUGE) Given a thermistor vacuum gauge, such as the A-14 "ANNIE" by Mechanical Refrigeration Enterprises, necessary instruction, and all tools and materials; use the thermistor vacuum gauge to determine the level of high vacuum obtained with a unit. |
| 7.05 | (USE ELECTRONIC TEMPERATURE ANALYZER) Given instruction, and electronic temperature analyzer, and all necessary accessories, and materials, and situations in which to measure temperatures quickly and accurately; orientation to proper use of the electronic temperature analyzer. |
| 7.06 | (USE MILLVOLT METER FOR MEASUREMENT OF SMALL VOLTAGES) Given instruction, a millivolt meter, and situation in which to measure a voltage of less than 1 volt; set up the millivolt meter, using the correct range, and properly measure a given situation to the instructor's standards. |

7.07 (USE THE VOLT-OHM-METER /VOM/) Given a typical VOM with AC, DC, and Ohms scales and leads, and instructions concerning its operation and various circuits requiring measurements; use the VOM to measure AC, DC, and Ohms and continuity.

7.08 (USE THE CLAMP-ON AMMETER) Given AC circuits to measure, a clamp-on ammeter or clamp-on attachment for a VOM, scale expander/multiplier, instruction on operating the clamp-on ammeter; measure given AC circuits to the standards of the instructor.

As a standard, the Amprobe Clamp-on meter is used. Outcome referenced tests may use visuals of various clamp-on ammeters as well as clamp-on attachments for the VOM.

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.01 USE CAPACITOR ANALYZER

---

PERFORMANCE OBJECTIVE:

Given a capacitor analyzer, capacitors or circuits to test, and instruction; check capacitors for leakage to the standards of the instructor. Emphasis will be on orientation to the use of the capacitor analyzer.

(NOTE: For the purpose of this description, the Watsco "Cappy" analyzer was used as a standard. Other instruments may follow different steps.)

PERFORMANCE ACTIONS:

7.0101 Select capacitor to be checked.

7.0102 Place selector switch in proper position.

7.0103 Attach test leads to terminals of capacitor being checked.

7.0104 Check for shorted, open, leaking, or good capacitor by pushing test switch. (NOTE: Some leakage typical.)

7.0105 Make current leakage test for electrolytics over 50 WVDC following manufacturer's instructions.

PERFORMANCE STANDARDS:

- Use the capacitor analyzer to check given capacitors for shorted, open, leaking, or good status.
- Performance process and findings must be to instructor's standards and procedures must be according to manufacturer's instructions.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Identification of different types of capacitors.
- Procedures/techniques for using the capacitor analyzer (demonstrated by instructor).

(NOTE: Use of VOM (DVM) often will be used for capacitor checks.)

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.02 USE THE HERMATIC ANALYZER

---

## PERFORMANCE OBJECTIVE:

Given a Hermatic Analyzer such as the "ANNIE" by Mechanical Refrigeration Enterprises, a compressor (stuck compressor) and required tools, equipment, and power sources; for orientation, use the hermatic analyzer to rock free a stuck compressor and to determine a faulty circuitry or components. Also, temporarily rely on the analyzer to support a refrigeration system, while replacement parts are being obtained.

(Orientation training for familiarization with Hermatic Analyzer)

## PERFORMANCE ACTIONS:

7.0201 Check hermatically sealed compressor for grounds, shorts, and continuity following manufacturer's instruction book.

7.0202 Start a hermatically sealed unit following manufacturer's instructions.

7.0203 Release a stuck or frozen unit following manufacturer's instructions.

7.0204 Test capacitors with the analyzer.

7.0205 Measure external (line) voltage with the analyzer.

## PERFORMANCE STANDARDS:

- Use the Hermatic Analyzer to attemp to rock free a stuck compressor and to determine a faulty circuitry or components. Also, rely on temporary analyzer to support a refrigeration system, while replacement parts are being obtained.
- Use the analyzer capacitors and, if included in the model, use the capacitor start units.
- Performance process must be to instructor's standards.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Safety in use of tester.
- Care of analyzer: Set up, techniques of using, and maintenance such as cleaning and battery replacement.

TASK 7.03 (Orientation) USE ELECTRONIC LEAK DETECTOR

---

PERFORMANCE OBJECTIVE:

Given an Electronic Halogen Leak Detector, power source, refrigerant system to check for leaks, and necessary instruction, tools, and materials; check for leaks.

PERFORMANCE ACTIONS:

7.0301 Assemble tester and materials for electronic leak detector test.

7.0302 Plug detector into power source.

a. Check for unit warming up immediately.
b. Check for sufficient air-flow according to manufacturer's procedures (i.e., and air flow ball in probe rises).

7.0303 Place sensitivity switch in high or low positions:

a. Use low range for big leaks.
b. Use high range for small leaks.
(NOTE: Unit may not be usable in highly contaminated area. If unit cannot be balance for conditions, use alternate methods.)

7.0304 Use reference leak to balance tester or check operation.

7.0305 Test for leaks, observing the indication (hose or audio), passing probe slowly over seams and joints, etc.

PERFORMANCE STANDARDS:

- Use Electronic Halogen Leak Detector following prescribed procedures to determine refrigerant leaks in given system.
- Performance procedures must be to instructor's standards and manufacturer's recommendations must be observed.

SUGGESTED INSTRUCTION TIME:

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.03 USE ELECTRONIC LEAK DETECTOR (Con't.)

---

RELATED TECHNICAL INFORMATION:

- Safety.
- Do not use the Electronic Leak Detector in a combustible atmosphere.
- Use of reference leak for balancing tester.
- Proper operation of detector.
- Alternate methods of testing for refrigeration leak.

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.04 THERMISTOR VACUUM GAUGE

---

PERFORMANCE OBJECTIVE:

Given a Thermistor Vacuum Gauge, such as the A-14 "Annie" by Mechanical Refrigeration Enterprises, necessary instruction, and all tools and materials; use the Thermistor Vacuum Gauge to determine the level of high vacuum obtained with a unit.

PERFORMANCE ACTIONS:

7.0401 Assemble tester and materials.

7.0402 Adjust meter:

a. Turn on.
b. Place in adjust mode.
c. Adjust meter control according to instruction manual.

7.0403 Adjust temperature compensation:

a. Adjust meter.
b. Plug sensor into cable.
c. Switch unit on.
d. Switch unit to "READ".
e. Set temperature compensation control per manual.
f. Adjust meter according to manual.

7.0404 Read vacuum:

a. Make above adjustments (steps 2 and 3).
b. Connect sensor to system being evacuated making good seal.
c. Switch on.
d. Switch to "READ".
e. Start vacuum pump.
f. Read vacuum as system is evacuated.
g. Recalibrate tester if test is being conducted over a period of time (step 2).

PERFORMANCE STANDARDS:

- Using the Thermistor Vacuum Gauge, read the vacuum on a given system being evacuated.
- Performance process must be to instructor' standards and readings must agree with those of the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Care of tester.

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.05 USE ELECTRONIC TEMPERATURE ANALYZER*

---

PERFORMANCE OBJECTIVE:

Given instruction, and Electronic Temperature Analyzer, and all necessary accessories, and materials, and situations in which to measure temperatures quickly and accurately; orientation to proper use of the Electronic Temperature Analyzer.

PERFORMANCE ACTIONS:

7.0501 Assemble Electronic Temperature Analyzer.

7.0502 Turn instrument selector to adjust position.

7.0503 Set to low or proper range.

7.0504 Adjust meter following instruction manual.

7.0505 Insert temperature probe(s) in instrument.

7.0506 Place probe securely on surface being measured (for thermal bond).

7.0507 Read temperature on proper scale.

7.0508 When completed, turn meter off, and return to storage.

PERFORMANCE STANDARDS:

- Orientation to proper set up and use of Electronic Temperature Analyzer to quickly and accurately measure surface temperature of given situations.
- Performance process must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Care of Electronic Temperature Analyzer.

*If available/servicable.

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.06 USE MILLIVOLT METER FOR MEASURFMENT OF SMALL VOLTAGES

---

## PERFORMANCE OBJECTIVE:

Given instruction, a millivolt meter, and situation in which to measure a voltage of less than 1 volt; set up the millivolt meter, using the correct range, and properly measure a given situation to the instructor's standards.

## PERFORMANCE ACTIONS:

7.0601 Assemble the millivolt meter.

7.0602 Select the proper scale, as provided: 0-50 MV, 0-500 MV, or 1 volt range.

7.0603 Insert tests leads according to instruction manual.

7.0604 Connect test probes across circuit being measured.

7.0604 Read millivoltage on appropriate scale. If appropriate, multiple actual reading by correct value to obtain voltage being read.

(NOTE: Millivolt meter may be replaced with DVM with scale reading less than 1 volt.)

## PERFORMANCE STANDARDS:

- Use the millivolt meter, to make measurements of less than 1 volt using procedures established by the manufacturer's instruction manual and to the standards of the instructor.
- Measurements should be with the accuracy specified by the instructor.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Safety.
- Care and use of millivolt (or DVM) meter.
- Procedures for making measurements (e.g., starting at highest scale, observing polarity).

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.07 USE THE VOLT-OHM-METER (VOM)

---

PERFORMANCE OBJECTIVE:

Given a typical VOM with AC, DC, and Ohms scales and leads, and instructions concerning its operation and various circuits requiring measurements; use the VOM to measure AC, DC, and Ohms and continuity.

PERFORMANCE ACTIONS:

7.0701 Assemble the VOM and leads.

7.0702 Set the VOM on the proper scale for the reading to be taken.

7.0703 Check to be sure the leads (test probes) are in the correct jacks.

7.0704 Check to be sure the Function Switch is on the correct scale/function.

7.0705 Measure (read):

a. AC
b. DC
c. Read resistance (ohms)
d. Use the VOM to check continuity

PERFORMANCE STANDARDS:

- Demonstrate the proper set up, use, and care of the VOM to measure DC, AC, Ohms, and continuity.

SUGGESTED INSTRUCTION TIME:

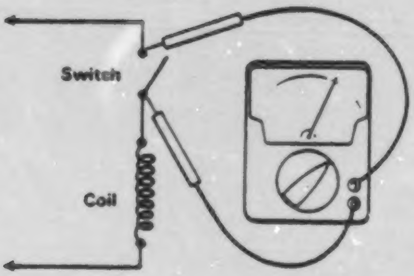
RELATED TECHNICAL INFORMATION:

- VOM theory and operation.
- Techniques for using VOM (measure from highest scale down, etc.).
- Use of VOM to measure voltage, resistance.
- Use of VOM for continuity measurement.
- Use of VOM with solid state circuits such as thermostats, controls.
- Safety.
- Reading the "D.V.M."

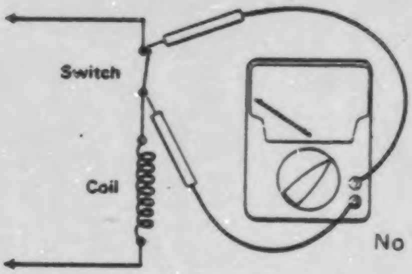
# VOLTAGE CHART

## VOLTAGE CHECK — SWITCHES OR CONTACTS

(Disconnect Switch, Thermostat, Heat Relay Contacts, Blower Control Contacts, Limits)



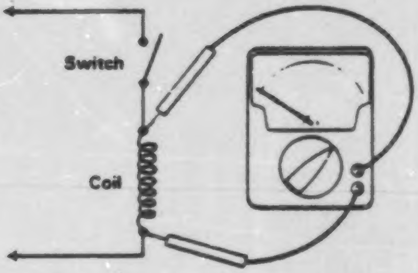
Voltage = Switch Open



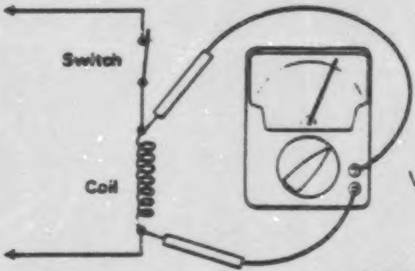
No Voltage = Switch Closed

## SERVICE CHECK FOR RESISTIVE LOADS

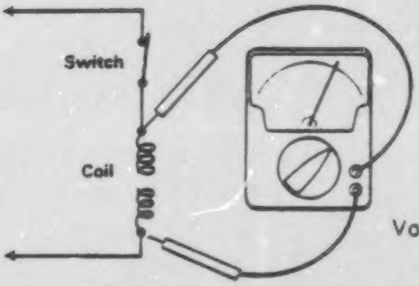
## VOLTAGE CHECK—COILS (Transformer, Heat Elements, Heat Relay Heater, Motor Windings)



No Voltage = Coil Not Energized



Voltage = Power to Coil
(See Note)



Voltage = Power to Coil
(See Note)

**NOTE:** The last two examples of a voltage check on a coil give the same meter reading, even though the coil is good in the first example and bad in the second example. The voltage check indicates only that there is power to the coil. A continuity check must be made to determine the condition of the coil.

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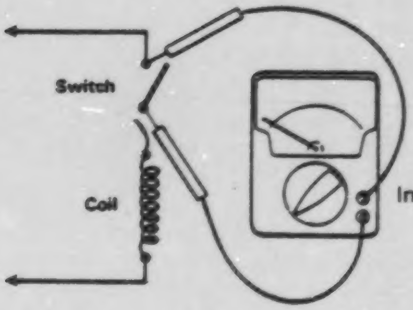
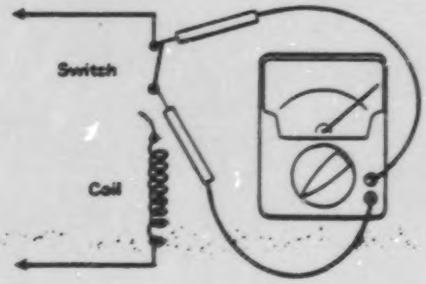
# CONTINUITY CHART

## CONTINUITY CHECK—SWITCHES (Disconnect Switch, Thermostat, Heat Relay Contacts, Blower Control Contacts, Limits)

**NOTE: The disconnect switch must be off to make a continuity (resistance) check. The component part to be checked must be isolated. To isolate a component part, remove one of the wires to the component. To make the continuity check, put the multimeter leads on the component part terminals.**

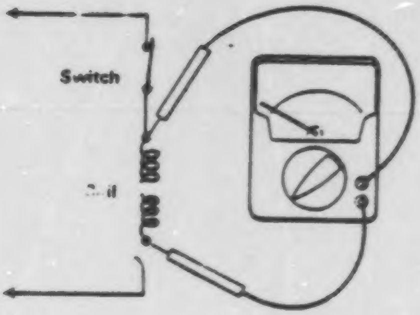


Infinite Reading = Switch Open

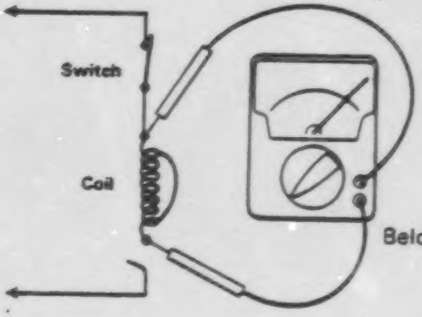


Zero or Less Than
One Ohm Reading = Switch Shorted
or Switch Closed

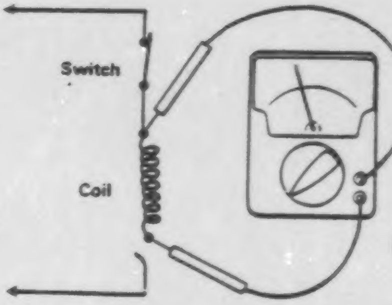
## CONTINUITY CHECK — COILS (Transformer, Heat Elements, Heat Relay Heater, Motor Windings)



Infinite Reading = Coil Open



Below Normal
Reading = Coil Shorted



Normal Reading = Coil Good

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UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.08 USE THE CLAMP ON AMMETER

---

PERFORMANCE OBJECTIVE:

Given AC circuits to measure, a clamp-on ammeter or clamp-on attachment for a VOM, scale expander/multiplier, instruction on operating the clamp on ammeter; measure given AC circuits to the standards of the instructor.

As a standard, the Amprobe clamp-on meter is used. Outcome referenced tests may use visuals of various clamp on ammeters as well as clamp on attachments for the VOM.

PERFORMANCE ACTIONS:

7.0801 Assemble ammeter instrument and accessories needed.

7.0802 Release pointer lock. Zero meter.

7.0803 Select proper scale (usually starting at highest range).

7.0804 Open jaws, encircle one conductor, close jaws.

7.0805 Read amperage. Select appropriate scale for accurate reading.

7.0806 If scale cannot be read due to obstruction, lock meter needle, remove instrument from conductor and take reading. Release lock after reading.

7.0807 On completing measurement, lock pointer, store instrument in case, and return to proper storage.

PERFORMANCE STANDARDS:

- Properly set up, use, and care for clamp-on ammeter making AC amperage measurements to the standards of the instructor.

SUGGESTED INSTRUCTION TIME:

UNIT 7.0 HVAC TEST INSTRUMENTS

TASK 7.08 USE THE CLAMP ON AMMETER (Con't.)

RELATED TECHNICAL INFORMATION:

- Operation of ammeter.
- Use of multi-function clamp-on instrument for voltage or resistance or continuity checks.
- Use of multiplier attachment for 1X, 5X, 10X readings.
- Use of field expedient multiplier loop (10 turns = 10X).
- Safety.
- Zero setting ohms scale.
- Zero calibration of meter.

## INSTRUMENTS OMITTED FORM THIS UNIT

The following instruments are omitted form this unit, at this time, since the secondary programs do not have these instruments:

- Megga
- Phase Sequence Indicator
- Wattmeter

## RELATED UNITS FOLLOW

### CUTTING, BENDING, FITTING, SOLDERING AND BRAZING TUBING, AND PIPING

The design of this guide does not include modules consisting of units. Tubing, piping, soldering, and brazing units, because they may be related in training, may be taught as a "module" for instructional organization. Units of the module would be:

- -Tubing
- -Piping
- -Soldering
- -Brazing

## MINIMUM SUGGESTED TERMINOLOGY
## (Tubing, Piping, Solderin, and Brazing Units)

| | |
|---|---|
| AIR-ACETYLENE TORCH | Torch which used an acetylene cylinder only and gets the oxygen to support the flame through the surrounding air. |
| ALLOY | A metal substance made of two or more metals. |
| CAPILLARY ACTION | Manner in which molten solder is drawn into joint through proper application of heat. |
| ELECTRODE | Metal rod which conducts a current from the electrode holder to the metal being welded. |
| FLUX | a. Midly corrosive substance applied to a joint prior to soldering to prevent oxidation.<br>b. Chemical used to clean metals and to promote fusion during the soldering/brazing process or to prevent oxidation on surfaces that have been cleaned. |
| INNER CONE | Inner white part of nuetral flame. |
| NUETRAL FLAME | Burning of equal parts of oxygen and acetylene. |
| OXIDATION | Deposit formed by a metals reaction to oxygen (corrosive effect). |
| REGULATOR | Device for reducing high cylinder pressure to a low working pressure. |
| SILVER BRAZING | Joining two metals together with siver alloy at high temperature soldering. |
| SILVER SOLDER | A brazing alloy that contains some percentage of silver. |
| SOFT SOLDER | Solder with a low melting temperature, generally around 800 degrees F. |
| SOLDERING | Joining two metals by the adhesive of a low melting temperature metal. |
| TROY OUNCE | Unit of weight, 1/2 of a pound, used in describing silver solder. |

# HVAC
# TUBING, PIPING, SOLDERING, AND BRAZING
## SUGGESTED INSTRUCTION TIMES

The suggested instruction time has been totaled for the following units:

- Tubing
- Piping
- Soldering
- Brazing

TOTAL HOURS 45

# UNIT 8.0

# TUBING

## HVAC
## MINIMUM SUGGESTED TERMINOLOGY
## TUBING

| | |
|---|---|
| TUBE | Thin wall pipe which carries fluid, etc. |
| NOMINAL SIZE TUBING | Type tubing used on water lines, drains, and in other applications, but not used in connection with refrigerants. |
| ARC TUBING | Tubing manufactured specifically for air conditioning and refrigeration that is free of contaminants, sealed, and is measured by ouside diameter. |
| ANNEALED TUBING | Tubing which has been heat treated to soften it for easy bending. |
| HARD DRAWN | Rigid copper tubing that should not be bent. |
| FLARE | Enlargement at end of piece of tubing which is made at a 45 degree angle and enables a fitting to be paced on the tubing. |
| SWEAT | Method of soldering tubing |
| COMPRESSION FITTING | Tubing connector consisting of a nut, sleeve, and union. |
| QUICK CONNECT | Fitting which permits fast and easy connecting of refrigerant lines. |

# HVAC
# TUBING
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 8.0 | TUBING | |
| 8.01 | Identify Types of Tubing and Fittings | |
| 8.02 | Cut Tubing as Required | |
| 8.03 | Bend Tubing | |
| 8.04 | (ORIENTATION) Recognize How to Identify and Dislodge Restriction from Tubing | |
| 8.05 | Flare and Connect Copper Tubing | |
| 8.06 | Construct a Swage Joint | |
| | TOTAL HOURS | ____ |

# TASK LISTINGS
# HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 8.0 | TUBING |
| 8.01 | (IDENTIFY TYPES OF TUBING AND FITTINGS) Given instructions, orientation to samples of different types of tubing and fittings; identify tubing and fittings commonly used in HVAC systems. Performance must be to the instructor's standards. |
| 8.02 | (CUT TUBING AS REQUIRED) Given a tube cutter, with reamer attached or separate, ACR tubing, rule, and other necessary tools, including hacksaw, and pipe vise; cut tubing as required. |
| 8.03 | (BEND TUBING) Given bending tools and soft copper tubing to bend to specific angles, to include bends specified by the instructor without crimping or flattening the tubing. |
| 8.04 | (RECOGNIZE HOW TO IDENTIFY AND DISLODGE RESTRICTION FROM TUBING) Given the basic tool kit, leak detector, refrigerant, and tubing with restrictions; dislodge the restrictions and put system back together so there are no leaks. |
| 8.05 | (FLARE AND CONNECT COPPER TUBING) Given flaring tool and copper tubing, and necessary tools and materials; construct a flare connection to produce a tight seal and leakproof connection when pressurized. |
| 8.06 | (CONSTRUCT A SWAGE JOINT) Given swaging tools and swaging vise, soft copper tubing, construct a swage joint. The joint will be the depth of the O.D. size of the tubing and will not fall out when inverted. |

UNIT 8.0 TUBING

TASK 8.01 IDENTIFY TYPES OF TUBING AND FITTINGS

---

PERFORMANCE OBJECTIVE:

Given instruction, orientation to samples of different types of tubing and fittings; identify tubing and fittings commonly used in HVAC systems. Performance must be to the standards of the instructor.

PERFORMANCE ACTIONS:

8.0101 Identify kinds of tubing and typical uses:

a. Copper tubing
   (1) Types:
      (a) Nominal size
      (b) ACR
   (2) Wall thickness:
      (a) K
      (b) L
      (c) M
      (d) DWV
   (3) Advantages and disadvantages

b. Aluminum tubing
   (1) Types:
      (a) Coiled seamless tube
      (b) Thin wall
   (2) Contamination prevention
   (3) Sizes
   (4) Advantages and Disadvantages
   (5) Connections

c. Steel tubing
   (1) Types:
      (a) Thin wall
      (b) Stainless
   (2) Connections:
      (a) Flaring
      (b) Braxing

8.0102 Identify common fittings used with different HVAC tubing:

a. Flared fittings
b. Flare to pipe fittings
c. Compression fittings
d. Sweat fittings
e. Hose fittings
f. Quick connect fittings

UNIT 8.0 TUBING

TASK 8.01 IDENTIFY TYPES OF TUBING AND FITTINGS

---

PERFORMANCE STANDARDS:

- Correctly identify common types of tubing and fittings used in HVAC systems, describe advantages and disadvatages of different types of tubing, and explain considerations in choosing tubing and fittings for HVAC sysyems. Performance must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Use of hand tools
- Measuring to fracitonal lengths
- Identification of different types of metal: Copper, aluminum, brass, steel, etc.

UNIT 8.0 TUBING

TASK 8.02 CUT TUBING AS REQUIRED

---

PERFORMANCE OBJECTIVE:

Given a tube cutter, with reamer attached or separate, ACR tubing, rule, and other necessary tools, including hacksaw, and pipe vise; cut tubing as required.

PERFORMANCE ACTIONS:

8.0201 Assemble tubing to be cut.

8.0202 Measure tubing for cut (length).

a. Cut tubing with tube cutter.
b. Cut larger hard copper tubing with a hand hacksaw using a holding vise to position the tubing for the cut.

(NOTE: Tubing should not be cut with the hacksaw using the leg as a support for the tubing.)

8.0203 After the tubing is cut, ream it to remove sharp burrs.

PERFORMANCE STANDARDS:

- Cut tubing using either a tube cutter or hacksaw depending on the type of tubing, reaming the tubing after the cut, without damage to the tubing.
- No fillings or chips should enter the tubing to be used.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Use of tubing cutter.
- Use of hacksaw.
- Use of holding device for hand sawing.
- Use of flaring back to hand cut tubing with hacksaw.
- Reaming.
- Measuring tubing.
- Pinching technique for sealing tubing.

UNIT 8.0 TUBING

TASK 8.03 BEND TUBING

---

## PERFORMANCE OBJECTIVE:

Given bending tools and soft copper tubing to bend to specific angles, to include bend specified by the instructor without crimping or flattening the tubing.

## PERFORMANCE ACTIONS:

8.0301 Assemble tubing and bending specifications.

8.0302 Assemble tube bending tools and equipment.

8.0303 Following procedures for tools used, bend tubing so no strain will be placed on fittings to be installed. Tubing should not kink and should remain round, not flattened or buckled. Maximum radius should be used to reduce flattening. Bend operation should be gradual.

## PERFORMANCE STANDARDS:

- Bend given tubing to the angles specified by the instructor without crimping, flattening, or damaging the tubing and so no strain is placed on fittings to be installed.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Safety in use of bending and cutting tools.
- Use of tube bending spring.
- Use of tube bender.
- Use of lever type tube bender.
- Measure of angle of bend.

UNIT 8.0 TUBING

TASK 8.04 (Orientation*) RECOGNIZE HOW TO IDENTIFY AND DISLODGE RESTRICTION FROM TUBING

---

PERFORMANCE OBJECTIVE:

Given the basic tool kit, leak detector, refrigerant, and tubing with restrictions; dislodge the restrictions and put system back together so there are no leaks.

PERFORMANCE ACTIONS:

8.0401 Attach gages.

8.0402 Determine location of restriction.

8.0403 Purge system.

8.0404 Cut pipe at point of restriction.

8.0405 Remove restriction.

8.0406 Join pipe.

8.0407 Evacuate system.

8.0408 Recharge system.

8.0409 Remove gages.

8.0410 Leak test tubing.

8.0411 Return system to operation.

PERFORMANCE STANDARDS:

- Dislodge restrictions from tubing using procedures recommended by instructor following proper procedures for diagnosis of restriction, restriction removal, and returning system to operation.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Use of basic hand tools, special tools, and testers.
- Basic tube work.
- Cleaning tubing in system.
- Joining pipe.
- Evaculating system, recharging system.
- Identify ACR tubing and typical sizes used in HVAC work.

UNIT 8.0 TUBING

TASK 8.05 FLARE AND CONNECT COPPER TUBING

---

PERFORMANCE OBJECTIVE:

Given flaring tool and copper tubing, and necessary tools and materials; construct a flare connection to produce a tight seal and leakproof connection when pressurized.

PERFORMANCE ACTIONS:

8.0501 A. SINGLE FLARE (Emphasis = 90+%)

(1) Ream tubing.
(2) Place flare nut on tubing.
(3) Place tubing in correct hole of flaring block.
(4) Place drop of oil on point of cone.
(5) Place flaring cone on block directly above tubing.
(6) Turn flaring cone clockwise slowly until flare is formed.

B. DOUBLE FLARE SCREW TYPE TOOL (Orientation/Option)

(1) Place female flare cone adaptor on end of tubing.
(2) Place point of flare cone in recess of adaptor.
(3) Put drop of oil on point of cone.
(4) Turn flare cone clockwise until inverted flare is formed.
(5) Place flare cone on tubing and turn clockwise until double flare is formed.

PERFORMANCE STANDARDS:

- Flare copper tubing to the standards of the instructor demonstrating proper techniques of working with copper tubing, flaring tools, and related tools and making an acceptable single flare, a double flare, and a punch type double flare.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Working with soft copper tubing, rolled tubing.
- Check flare connection by a source of appropriate pressure to line and conducting soap-water test.

UNIT 8.0 TUBING

TASK 8.06 CONSTRUCT A SWAGE JOINT

---

PERFORMANCE OBJECTIVE:

Given swaging tools and swaging vise, soft copper tubing, construct a swage joint. The joint will be the depth of the O.D. size of the tubing and will not fall out when inverted.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 8.0601 | Assemble tubing to be swaged. |
| 8.0602 | Select swaging tools. |
| 8.0603 | Clean parts to be joined, apply flux, and assemble them. |
| 8.0604 | Heat the assembly to the following temperature of the solder. |
| 8.0605 | Apply solder* so it flows into joint. |

PERFORMANCE STANDARDS:

- Construct a swage joint, mechancially joint tubing, and solder joint so joint does not leak under pressure.
- Flux applied must not build-up inside or get into system.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Handling soft copper pipe.
- Use of swaging tools.
- Soldering copper tubing.

*Use silver solder/brazing in non-training.

# UNIT 9.0

# SOLDERING

# HVAC
# SOLDERING
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 9.0 | SOLDERING | |
| 9.01 | Solder Soft Copper Tubing and Fittings | |
| 9.02 | Locate and Repair Leaking Solder Joint | |
| 9.03 | Silver Braze Tubing and Fittings (Copper-Brass-Steel) | |
| | TOTAL HOURS | |

## TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 9.0 | SOLDERING |
| 9.01 | (SOLDER SOFT COPPER TUBING AND FITTINGS) Given necessary hand tools; solder soft fittings to copper tubing and copper swage joints to form a tight seal and leakproof connection. |
| 9.02 | (LOCATE AND REPAIR LEAKING SOLDER JOINT) Given freshly or old soldered joint(s), leak test equipment, soldering tools, equipment, and all materials required; locate and fix a leak due to a faulty solder joint. Recommended procedures for repairing the leaking joint must be followed. |
| 9.03 | (SILVER BRAZE TUBING AND FITTINGS [Copper-Brass-steel]) Given brazing torch, silver solder, tools and equipment, and necessary materials, copper, brass, and steel to braze; silver braze the tubing and fittings to form a tight seal and leakproof connection. |

UNIT 9.0 SOLDERING

TASK 9.01 SOLDER SOFT COPPER TUBING AND FITTINGS

---

PERFORMANCE OBJECTIVE:

Given tubing, fitting(s), soldering equipment, and materials, and necessary hand tools; solder soft fittings to copper tubing and copper swage joints to form a tight seal and leakproof connection.

PERFORMANCE ACTIONS:

9.0101 Assemble tubing and fitting. (ACR or L tubing)

9.0102 Assemble soldering tools, equipment, and materials.

9.0103 Check to ensure that burrs have been removed from tubing.

9.0104 Clean joint. (Remove oxidation, oil, water, or grease which might prevent a good solder bond.)
(NOTE: Although joint may be further cleaned by applying chemically active fluxes, a common practice in plumbing work, this is not recommended for refrigeration work since the active chemicals which are almost impossible to keep out of the tubing interior are very damaging to refrigeration systems.)
(RECOMMENDED PROCEDURE: Standard practice for cleaning includes using shaped wire brushes, sandcloth, steel wool, or abrasive pads. Oxide and metal particles removed must be kept from the interior of the tubing.)
(CAUTION: Do not touch or blow on a cleaned surface. These actions may leave an acidic moisture or moisture which may interfer with bonding.)

9.0105 Give metal surface a thin coat of noncorrosive solder flux to prevent air from contacting surfaces.

9.0106 Make mechanical joint.*

9.0107 Light torch.

UNIT 9.0 SOLDERING

TASK 9.01 SOLDER SOFT COPPER TUBING AND FITTINGS

---

PERFORMANCE ACTIONS (Con't.):

9.0108 Adjust flame to soft blue outer cone.

9.0109 Apply heat to joint following procedures outlined by instructor.

9.0110 Heat until flux starts to bubble.

9.0111 Apply solder to joint and flow around joint by moving flame around joint.
(NOTE: It takes about 1 inch of 1/8 inch wire solder per 1 inch diameter joint: i.e., 1/2 inch per 1/2 inch diameter.)

9.0112 Allow joint to cool.

9.0113 Clean excess flux from joint.

9.0114 Pressurize and leak test.

PERFORMANCE STANDARDS:

- Soft solder fittings to copper tubing and swage joints so that there is a tight seal that is leakproof.
- Performance procedures must be to the instructor's standards and the finished soldered joint must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Soldering with torch.
- Soldering with oxyacetylene torch.
- Select proper fittings (size fittings).
- Cleaning techniques.
- Types of soft solder typically used: 50/50, 95/95.
- Apply solder flux.
- *Soft soldering brass fittings to copper tubing.
- *Soft soldering copper fittings to copper tubing.
- *Soft soldering copper ARC swage joints: Inverted and horizontal.

UNIT 9.0 SOLDERING

TASK 9.02 LOCATE AND REPAIR LEAKING SOLDER JOINT

---

PERFORMANCE OBJECTIVE:

Given freshly or old soldered joint(s), leak test equipment, soldering tools, equipment, and all materials required; locate and fix a leak due to a faulty solder joint. Recommended procedures for repairing the leaking joint must be followed.

PERFORMANCE ACTIONS:

9.0201 Assemble repair and diagnostic materials.

9.0202 Isolate the leak. Inspect joint.

9.0203 Make prelimary diagnosis:

a. If leak is caused by insufficient cleaning, the metal must be cleaned.
b. If leak is due to overheating, the metal must be cleaned before the solder will bond.
c. If leak is caused by distortion or pressure between tube and fitting that prevented solder from flowing into joint, the joint must be cleaned, fluxed, and soldered again.
d. If refrigerant was in tubing, the joint has been contaminated with oil and must be cleaned before solder will bond. (RECOMMENDATION: Only way to fix a leaking joint is to take it apart, clean it, and solder it again.)

9.0204 Heat joint and take it apart. Inspect to see why it leaked.

9.0205 Clean, flux, and, if possible, tin joint prior to reconnecting and soldering. (NOTE 1: If the system is sealed and the repair is being made on the last joint, air inside the tubes may expand and escape through the joint, preventing a good solder joint. If possible, open a mechanical union that will releave the pressure.)

UNIT 9.0 SOLDERING

TASK 9.02 LOCATE AND REPAIR LEAKING SOLDER JOINT

---

PERFORMANCE ACTIONS (Con't.):

(NOTE 2: Repairing leaks where the tubing has water or oil inside involves special considerations which will be outlined by the instructor. (e.g., drain the tubing, install a new fitting, etc.).

9.0206 Inspect repair.

PERFORMANCE STANDARDS:

- Locate and repair leaking solder joint, following recommended procedures and to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Soldering tubing to tubing or tubing to fitting.

UNIT 9.0 SOLDERING - BRAZING

TASK 9.03 SILVER BRAZE TUBING AND FITTINGS
(Copper - Brass - Steel)

---

PERFORMANCE OBJECTIVE:

Given brazing torch, silver solder, tools and equipment, and necessary materials, and copper, brass, and steel to braze; silver braze the tubing and fittings to form a tight seal and leakproof connection.

PERFORMANCE ACTIONS:

9.0301 Read literature accompanying fittings to determine if they can be brazed.

9.0302 Assemble tools, equipment, and materials for brazing as well as tubing and fittings to be brazed.

9.0303 Clean joint. Square and deburr it.
(NOTE: Cleaning may determine if the joint is tight or leaks later. Since it is less expensive to clean and flux a joint than it is to repair a joint poorly brazed, clean and flux copper tubing and brass fittings.)

9.0304 Apply thin coat of flux on joint (boric acid paste or equivalent). (A recommended procedure is to coat only the male section, allowing it to carry the flux to the female section of the joint, which should help prevent flux from entering the system.)

9.0305 Light torch.

9.0306 Adjust flame (same as for soldering).

9.0307 Braze metals following procedures outlined:

a. Use 45 percent silver alloy for copper to steel without using a nitrogen set up.
b. NOTE: To fill a joint, anticipate about 2 inches of eighth by sixteenth flat rod per inch diameter. Anticipate about 3 inches of sixteenth round wire rod per inch diameter to fill a joint.
c. Additional solder on the outside of the joint will not add strength.

TASK 9.03 SILVER BRAZE TUBING AND FITTINGS (Copper - Brass - Steel)

---

PERFORMANCE ACTIONS (Con't):

9.0308 Clean and inspect brazed joint.

PERFORMANCE STANDARDS:

- Silver braze copper, brass, and steel tubing and fittings to form a tight seal and leakproof connection to the standards of the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Silver solder: What type to select, how to use.
- Preparing joints.
- Heat temperatures for brazing.
- Identify which metals to heat first.
- Safety.

EXTENSION:

- Brazing copper-aluminum joints.
- Sealing copper-aluminum joints against air and moisture.

# UNIT 10.0

# PIPING

## HVAC
## PIPING
## SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 10.0 | PIPING | |
| 10.01 | Construct PVC Pipe Joint | |
| 10.02 | Thread Black Iron Pipe | |
| | TOTAL HOURS | ____ |

# TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 10.0 | PIPING |
| 10.01 | (CONSTRUCT PVC PIPE JOINT) Given PVC pipe of the correct size and type, fittings, solvent, ruler, and the necessary hand tools; construct a PVC pipe joint so that fitting is to the proper depth, sealed and will not leak under pressure. |
| 10.02 | (THREAD BLACK IRON PIPE) Given a die set, pipe, and necessary tools and materials; thread black iron pipe so it will mate with the same female fitting or pass through gauge inspection. |

UNIT 10.0 PIPING

TASK 10.01 CONSTRUCT PVC PIPE JOINT

---

PERFORMANCE OBJECTIVE:

Given PVC pipe of the correct size and type, fittings, solvent, ruler, and the necessary hand tools; construct a PVC pipe joint so that fitting is to the proper depth, sealed and will not leak under pressure.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 10.0101 | Assemble tools, ruler, and PVC materials. |
| 10.0102 | Measure line or joint. |
| 10.0103 | Cut PVC pipe to size. |
| 10.0104 | Prepare pipe (clean) and fitting according to instructions. |
| 10.0105 | Apply solvent. |
| 10.0106 | Twist joint according to given instruction. |
| 10.0107 | Allow pipe joint to set. |
| 10.0108 | Inspect joint and pressure test it. |

PERFORMANCE STANDARDS:

- Construct PVC pipe joints according to given specifications so the fittings is to the proper depth, is sealed, and will not leak under pressure.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Measuring.
- Cutting PVC pipe: Use of hacksaw, selection of blade.
- Preparation of joint.
- How to join PVC joint properly.
- Safety.

UNIT 10.0 PIPING

TASK 10.02 THREAD BLACK IRON PIPE

---

PERFORMANCE OBJECTIVE:

Given a die set, pipe, and necessary tools and materials; thread black iron pipe so it will mate with the same size female fittings or pass through gage inspection.

PERFORMANCE ACTIONS:

10.0201 Assemble tools and equipment.

10.0202 Assemble pipe.

10.0203 Measure pipe for length.

10.0204 Determine thread size (threads per inch) using chart or specifications.

10.0205 Turn threads on pipe with given pipe threader.

10.0206 Clean end of threaded pipe.

10.0207 Connect threaded pipe as required, using pipe joint compound if required.

PERFORMANCE STANDARDS:

- Thread given black iron pipe so that it will mate with the same size female or pass through gage inspection.
- The instructor's standards for performance process and product must be met.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify different types of pipe material.
- Identify different types of fittings:
  - close nipple
  - short and long nipple
  - coupling
  - offset
  - ground-joint union
  - reducers
  - bushings
  - elbows
  - union tees
  - return bends
  - T's
  - Y branches
  - side outlet elbows
  - return bend with outlet
  - pipe plug
  - pipe cap
  - right and left hand center nipple
- Use of pipe threader.
- Cutting pipe to size; pipe vise.
- Pipe fitting measurements.

# UNIT 11.0

# ELECTRICAL WIRE CONNECTIONS

# HVAC
# ELECTRICAL WIRE CONNECTIONS
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 11.0 | ELECTRICAL WIRE CONNECTIONS | |
| 11.01 | Crimp Wire to Terminal Using Crimping Tool | |
| 11.02 | Splice Wires Using Solderless Connectors (Wire Nuts) | |
| 11.03 | Splice Wires | |
| 11.04 | (OPTIONAL) Solder Electrical Conductors and Connections | |
| | TOTAL HOURS | ____ |

# TASK LISTINGS
# HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 11.0 | ELECTRICAL WIRE CONNECTIONS |
| 11.01 | (CRIMP WIRE TO TERMINAL USING CRIMPING TOOL) Given stranded electrical wire of the size typically encountered in HVAC residential systems, crimping tool, terminal connectors, and necessary tools or materials; strip insulation from the wire to an appropriate length and crimp the required terminal on the bare wire. |
| 11.02 | (SPLICE WIRES USING SOLDERLESS CONNECTORS /WIRE NUTS/) Given electrical wire of the type typically encountered in residential HVAC systems, wire nuts, wire stripper, knife, or crimper with stripping capability; strip insulation from two or more wires and splice them so that a proper mechanical and electrical connection is made. Install wire nut on splice. |
| 11.03 | (SPLICE WIRES) Given different wire sizes and the need for splicing two or more wires in a circuit, knife, wire splicing tools or wire strippers, hermetic sealer or insulating compound, soft rubber or equivalent tape, plastic electrical tape, compression splice connectors, crimp tool, wire nuts, lug terminals, and other materials as required; splice wires as required by instructions or schematic to complete a circuit so that connections are mechanically and electircally secure. Performance must adhere to safe practices, standard approved techniques, and must be acceptable to the instructor. |
| 11.04 | (SOLDER ELECTRICAL CONDUCTORS AND CONNECTIONS) Given tools, equipment, and materials including a soldering gun/iron and electrical solder and wiring or electrical connections to solder; solder the electrical wires or terminals so that a tight mechanical and electircal bond is formed. |

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.01 CRIMP WIRE TO TERMINAL USING CRIMPING TOOL

---

## PERFORMANCE OBJECTIVE:

Given stranded electrical wire of the size typically encountered in HVAC residential systems, crimping tool, terminal connectors, and necessary tools or materials; strip insulation from the wire to an appropriate length and crimp the required terminal on the bare wire.

## PERFORMANCE ACTIONS:

11.0101 Remove insulation from about 1/4 inch (or length recommended by instructor) or wire:

- a. Crimp Tool Method:
  - (1) Insert wire into proper skinning hole.
  - (2) Squeeze handles of crimping tool closed.
  - (3) Rotate crimping tool around wire to insure a clean cut.
  - (4) Hold wire firmly while pulling crimping tool away from wire to remove insulation.
- b. Using knife:
  - (1) Carefully cut insulation at slight angle to just tough wire (avoid nicking wire).
  - (2) Carefully pull insulation from wire so wire is not cut or nicked with knife.

11.0102 Insert bare wire into end of terminal of proper type and size (Wire may be twisted first).

11.0103 Place jaws of crimping tool around end of terminal.

11.0104 Close crimping tool around terminal end.

11.0104 Squeeze terminal onto wire.

11.0105 Check connection by pulling terminal: If terminal begins to slide on wire, crimp again.

## PERFORMANCE STANDARDS:

- Crimp terminal connector onto wire so that a secure mechanical and electrical connection is made.

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.01 CRIMP WIRE TO TERMINAL USING CRIMPING TOOL (Con't.)

---

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- How to strip insulation from wire.
- Different types of terminal connectors.
- Crimping tool.
- Safety considerations.
- Potential for damaging wire by nicks or cuts.

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.02 SPLICE WIRES USING SOLDERLESS CONNECTORS (WIRE NUTS)

---

PERFORMANCE OBJECTIVE:

Given electrical wire of the type typically encountered in residential HVAC systems, wire nuts, wire stripper, knife, or crimper with stripping capibility; strip insulation from two or more wires and splice them so that a proper mechanical and electrical connection is made. Install wire nut on splice.

PERFORMANCE ACTIONS:

11.0201 Remove proper length of insulation from wires to be spliced (considering wire size and wire nut).

11.0202 Twist stranded wire together (each wire) as instructed.

11.0203 Make proper type of wire splice for job:

- Pigtail
- Tap or end splice

11.0204 Check to see if splice connection is mechanical and electrical secure.

11.0205 Install proper size wire nut tightly on splice so that no exposed wire extends outside of wire nut.
(ALTERNATE: Install insulated crimp connector on wire splice.)

PERFORMANCE STANDARDS:

- Splice wires using solderless connector so that the connection is mechanically and electrically secure.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Removing insulation from wire.
- Making secure splice of two or more wires.
- Different types of solderless connectors approved by local codes.
- Safety considerations.

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.03 (OPTIONAL) SPLICE WIRES

---

PERFORMANCE OBJECTIVE:

Given different wire sizes and the need for splicing two or more wires in a circuit, knife, wire splicing tools or wire strippers, hermetic sealer or insulating compound, soft rubber or equivalent tape, plastic electrical tape, compression splice connectors, crimp tools, wire nuts, lug terminals, and other materials as required; splice wires as required by instructions or schematic/diagram to complete a circuit so that connections are made mechanically and electrically sound. Performance must adhere to safe practices, standard approved tenhniques, and must be acceptable to the instructor.

PERFORMANCE ACTIONS:

11.0301 Review diagram or instructions concerning wiring circuit.

11.0302 Determine splices to be made and the type of splice for each situation.

11.0303 Assemble materials and tools.

11.0304 Disconnect power from circuit, removing fuse or switching off circuit breaker or main power switch. (Recommendation: If power switch, etc., is located away form work area, mark switch to alert others that work is being done on circuit. [e.g., DANGER!])

11.0305 Strip insulation from wires to be spliced.

11.0306 Make acceptable splice of wires:
a. Two wires of same size
b. Tee-tap splice
c. Large and small wire
d. 3 or more wires (Demonstrate how to splice beyond range of splice cap)

11.0307 Secure splice with crimp, wire nut, or other acceptable method.

11.0308 As appropriate, seal splice from oxidation, using compound, soft tape, and plastic electrical tape.

11.0309 Check circuit.

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.03 SPLICE WRIES (Con't.)

PERFORMANCE STANDARDS:

- Make acceptable slice of two or more wires to complete a given circuit using best method for situation. Observe safe practices in working with electrical circuits. Splice must be mechanically and electrically secure and must be protected form oxidation and insulated properly. Lugs must be safety located.
- Wiring must be completed with appropriate color wires and diagrams/ schematic of the circuit must be updated.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify different methods of splicing wires.
- Identify different types of compression splices.
- Explain how to prevent oxidation of electrical connectors.
- Identify major types of electrical connectors/lugs for terminals.
- Explain steps to take in splicing more than two wries, wires of different sizes, etc.
- Identify safety considerations.

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.04 (Optional) SOLDER ELECTRICAL CONDUCTORS AND CONNECTIONS

---

PERFORMANCE OBJECTIVE:

Given tools, equipment, and materials including a soldering gun/iron and electrical solder and wiring or electrical connections to solder; solder the electrical wires or terminals so that a tight mechanical and electrical bond is formed.

PERFORMANCE ACTIONS:

11.0401 Assemble tools, equipment, and materials.

11.0402 Identify wires, terminals, etc., to be soldered.

11.0403 Remove about 1/4 inch (or appropriate length) insulation from wires and clean wires being careful not to cut them.

11.0404 Twist wires together to form a united conductor (Wire may be thinned to promote soldering to connectors, etc.).

a. Splice two wires together.
b. Connect wire to terminal.
c. Connect component to terminal.

11.0405 Solder mechanical/electrical connection allowing solder to flow on heated joint.

11.0406 Allow solder to cool.

11.0407 Check connection.

11.0408 Clean and tape joint tightly with two or more layers of recognized electrical tape to ensure that no electrical hazard is exposed. (Use heat shrink tubing or tape, if required/recommended.)

PERFORMANCE STANDARDS:

- Solder given electrical conductors and connections using proper solder and soldering methods/techniques so that the soldered connections are mechanically and electrically bonded together.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Preparing wire for splicing, connecting to terminals, etc.
- Tinning wires, terminals.
- Use of soldering iron/gun, including tinning.
- Selection of electrical solder (50/50 Rosin-core).
- Making good mechanical connections.
- Safety.

# UNIT 12.0

# WIRING DIAGRAMS

Besides introducing the secondary student to common HVAC wiring diagrams, this unit is designed to promote a high degree of transfer of knowledges and skills in interpreting wiring diagrams from the classroom to practical field situations.

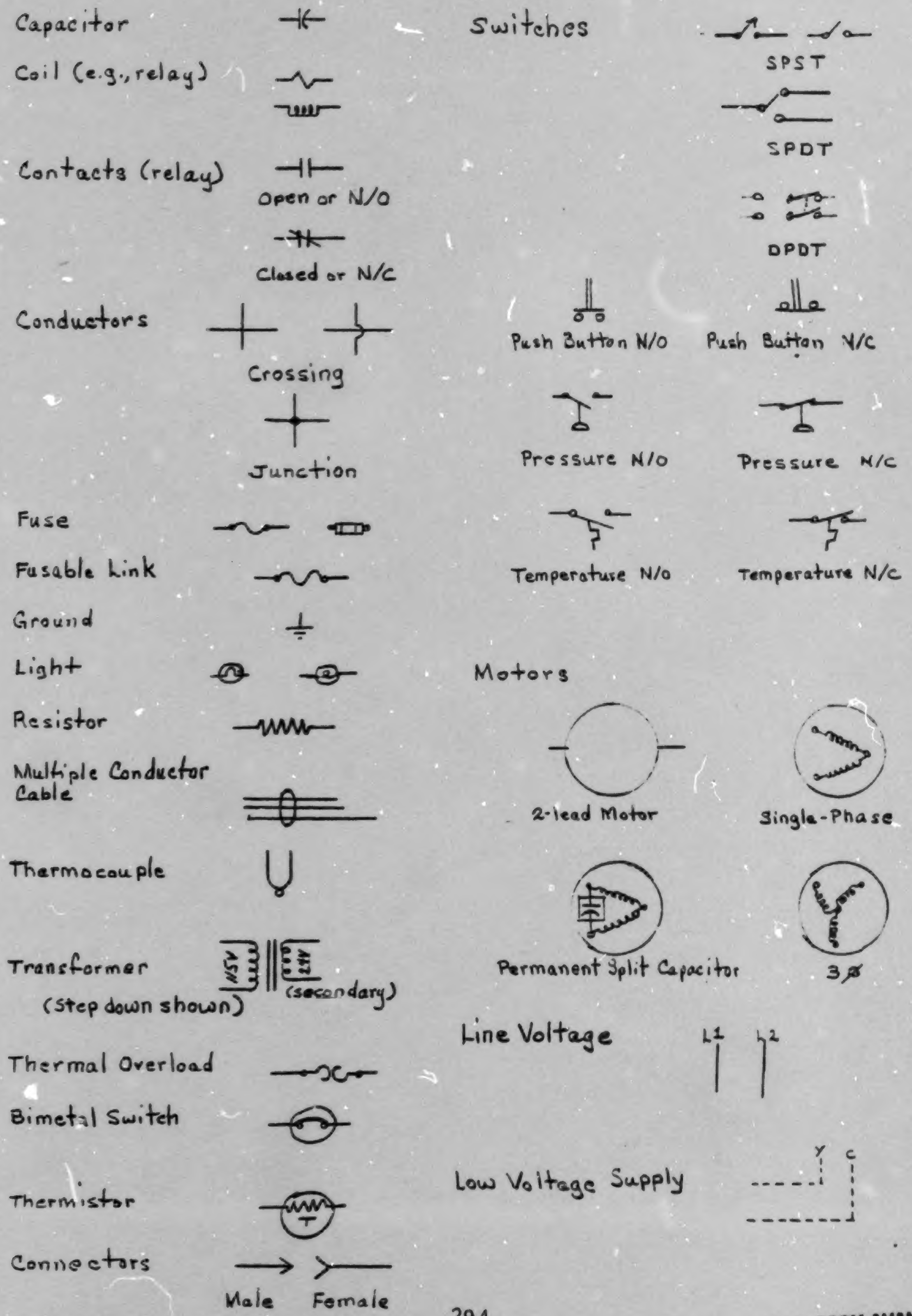
Typical tasks may include drawing schematics of circuits according to given information, to represent given systems/units, or to transfer pictorial information to schematics.

Learning experiences may encompass projects that integrate tasks described in this unit with other tasks and units. Emphasis will be on helping the student develop competence in interpreting diagrams of basic HVAC systems.

## MINIMUM SUGGESTED TERMINOLOGY
## HVAC

| | |
|---|---|
| LADDER SCHEMATIC | Line drawing using symbols for circuit components with each leg of the power supply representing the side rails of the ladder and the parallel circuits across the lines forming the rails. |
| PICTORIAL | Wiring diagram using pictures or representations of components positioned as they are located in the system. |
| SYMBOL | Standardized drawing which represents a component in a wiring diagram. |
| WIRING DIAGRAM | Drawing of electrical circuits. |

# SCHEMATIC SYMBOLS


Capacitor
Coil (e.g., relay)
Contacts (relay)
Open or N/O
Closed or N/C
Conductors
Crossing
Junction
Fuse
Fusable Link
Ground
Light
Resistor
Multiple Conductor Cable
Thermocouple
Transformer
(Step down shown)
120V
24V
(secondary)
Thermal Overload
Bimetal Switch
Thermistor
T
Connectors
Male
Female
Switches
SPST
SPDT
DPDT
Push Button N/O
Push Button N/C
Pressure N/O
Pressure N/C
Temperature N/O
Temperature N/C
Motors
2-lead Motor
Single-Phase
Permanent Split Capacitor
3Ø
Line Voltage
L1
L2
Low Voltage Supply
Y
C

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# HVAC
# WIRING DIAGRAMS
# SUGGESTED INSTRUCTION TIMES

| HVAC<br>UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 12.0 | WIRING DIAGRAMS | |
| 12.01 | Draw Basic Schematic Wiring Diagrams | * |
| 12.02 | Draw Current Relay Wiring Schematic | * |
| 12.03 | Draw a Potential Relay Wiring Diagram | * |
| 12.04 | Draw Hot-Wire Relay in Circuit | * |
| 12.05 | Draw a Gas Furnace Wriing Diagram | * |
| 12.06 | Draw an Outdoor Condensing Unit Wiring Diagram | * |
| 12.07 | Draw Wiring Diagram for an Electric Furnace | * |
| 12.08 | Draw Wiring Diagram of Split Heat and Cool System | * |
| 12.09 | Draw a Wiring Diagram for a Refrigerator | * |
| 12.10 | Draw a Ladder Wiring Diagram of a Window Air Conditioner | * |
| 12.11 | Draw Schematic Wiring Diagram of Low Voltage Control Circuit | * |
| | TOTAL HOURS | 30 |

* - Total Time Estimated

## TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 12.0 | WIRING DIAGRAMS |
| 12.01 | (DRAW BASIC SCHEMATIC WIRING DIAGRAMS) Provided with a simple pictorial drawing of a HVAC system, references, pencil and paper, and other required materials; draw a basic wiring schematic diagram according to pictorial and other information given. The schematic diagram must match the pictorial diagram. |
| 12.02 | (DRAW CURRENT RELAY WIRING SCHEMATIC) Given a HVAC system with a compressor motor controlled by a current relay switched by a thermostat or manual control and operated off a 120 volt AC source; draw a schematic wiring diagram showing the current relay. Include an overload control in the common side of the compressor motor power source and indicate a start capacitor in the proper lead of the compressor motor. |
| 12.03 | (DRAW A POTENTIAL RELAY WIRING DIAGRAM) Draw a schematic of a potential relay used in a circuit to control a compressor. Show the start capacitor with a shunt resistor across the capacitor. The relay is to be of the NC type. The schematic must conform to standard circuits found in HVAC systems and be acceptable to the instructor. |
| 12.04 | (DRAW HOT-WIRE RELAY IN CIRCUIT) Draw a schematic of a hot-wire relay controlling a compressor motor operated form a 120 VAC line. Show a thermostat between the relay and line. The diagram must agree with given information and the circuit must operate if constructed. |
| 12.05 | (DRAW A GAS FURNACE WIRING DIAGRAM) Provided with a gas furnace properly wired, draw a schematic wiring diagram of the furnace using the proper symbols for components. The schematic must match the wiring of the furnace. |
| 12.06 | (DRAW AN OUTDOOR CONDENSING UNIT WIRING DIAGRAM) Given an outdoor condensing unit or simulation, draw a schematic of the condensing unit that matches the wiring of the unit. |
| 12.06 | (DRAW A WIRING DIAGRAM FOR AN ELECTRIC FURNACE) For a given electric furnace, draw a schematic diagram that matches the wiring in the furnace. |

12.08 (DRAW WIRING DIAGRAM OF SPLIT HEAT AND COOL SYSTEM) Given a sample or description of a split heat and cool system, draw a wiring diagram of the system.

12.09 (DRAW A WIRING DIAGRAM FOR A REFRIGERATOR) Given a refrigerator, draw a schematic diagram of the refrigerator wiring. The diagram must match the wiring of the refrigerator.

12.10 (DRAW A LADDER WIRING DIAGRAM OF A WINDOW AIR CONDITIONER) Provided with a window air conditioner, draw a ladder schematic wiring diagram that matches the wiring of the unit.

12.11 (DRAW SCHEMATIC WIRING DIAGRAM OF LOW VOLTAGE CONTROL CIRCUIT) Provided with an actual, simulated, or description of a low voltage control system, draw a schematic diagram that accurately represents the low voltage system.

UNIT 12.0 WIRING DIAGRAMS

TASK 12.01 DRAW BASIC SCHEMATIC WIRING DIAGRAM

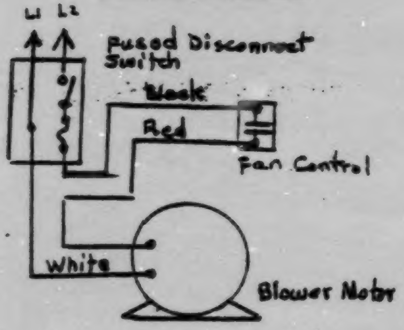
PERFORMANCE OBJECTIVE:

Provided with a simple pictorial drawing of a HVAC system, references, pencil and paper, and other required materials; draw a basic wiring schematic diagram according to pictorial and other information given. The schematic diagram must match the pictorial diagram.

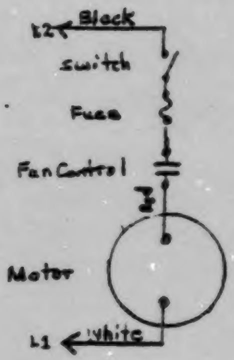
PERFORMANCE ACTIONS:

12.0101 Draw required diagram. (See answer below.)

PICTORIAL


L1
L2
Fused Disconnect Switch
Black
Red
Fan Control
White
Blower Motor

SCHEMATIC


L2
Black
switch
Fuse
Fan Control
Motor
L1
White

PERFORMANCE STANDARDS:

- Draw a basic schematic wiring diagram for a given HVAC system based on a pictorial drawing and other information provided by the instructor.
- The schematic wiring diagram must match the pictorial diagram.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify HVAC wiring symbols used in pictorial and schematic diagrams.
- Identify and draw basic symbols such as resistors, relays, and motors from memory.
- Identify reference sources and locate schematic or pictorial symbols representing components of an HVAC system.

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UNIT 12.0 WIRING DIAGRAMS

TASK 12.02 DRAW CURRENT RELAY WIRING SCHEMATIC

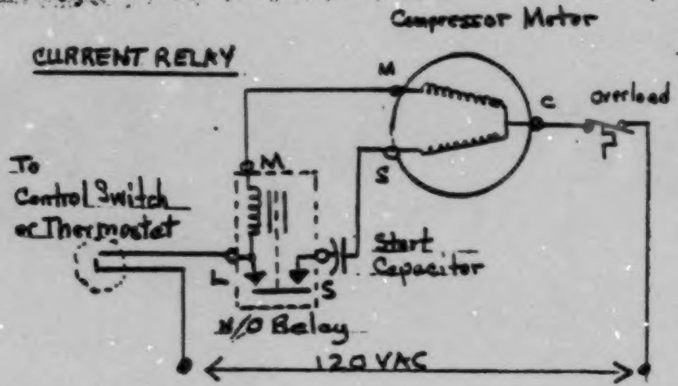
---

PERFORMANCE OBJECTIVE:

Given a HVAC system with a compressor motor controlled by a current relay switched by a thermostat or manual control and operated off of a 120 volt AC source, draw a schematic wiring diagram showing the current relay. Include an overlaod control in the common side of the compressor motor power source and indicate a start capacitor in the proper lead of the compressor motor.

PERFORMANCE ACTIONS:

12.0201 Draw schematic of current relay controlling a compressor. (See sample wiring schematic. Pictorial omitted.)


Compressor Motor
CURRENT RELAY
M
C
overload
S
M
To Control Switch or Thermostat
L
S
Start Capacitor
N/O Relay
120 VAC

PERFORMANCE STANDARDS:

- Draw a current relay wiring schematic based on a circuit description provided by the instructor (or as stated in the objective).
- The circuit drawn must conform to accepted practices of the trade and must operate if constructed.

SUGGESTED INSTRUCTION TIME:

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TASK 12.02 DRAW CURRENT RELAY WIRING SCHEMATIC (Con't.)

---

RELATED TECHNICAL INFORMATION:

- Identify pictorial symbols.
- Identify schematic wiring symbols.
- Describe the operation of a current relay.
- Describe typical applications of the current relay.
- Describe the purpose of a start capacitor.
- Describe the function of an overload control.

UNIT 12.0 WIRING DIAGRAMS

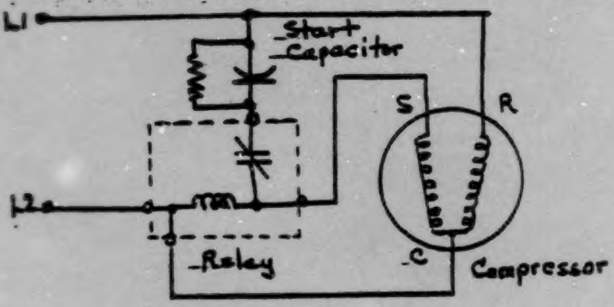
TASK 12.03 DRAW A POTENTIAL RELAY WIRING DIAGRAM

## PERFORMANCE OBJECTIVE:

Draw a schematic of a potential relay used in a circuit to control a compressor. Show the start capacitor with a shunt resistor across the capacitor. The relay is to be of the NC type. The schematic must conform to standard circuits found in HVAC systems and be acceptable to the instructor.

## PERFORMANCE ACTIONS:

12.0301 Draw a schematic of a potential relay controlling a compressor. (See sample schematic. Pictorial omitted.)



POTENTIAL RELAY

## PERFORMANCE STANDARDS:

- Draw a potential relay wiring schematic where the compressor is controlled by a NC relay.
- Show the start capacitor with a shunt resistor across it.
- The circuit drawn must be acceptable to the instructor and it must operate if constructed.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Describe the operation of a potential relay.
- Identify/draw the symbol for a potential relay.
- Sketch/describe the internal layout of a potential relay.
- Describe typical applications of the potential relay.

UNIT 12.0 WIRING DIAGRAMS

## TASK 12.04 DRAW HOT-WIRE RELAY IN CIRCUIT

---

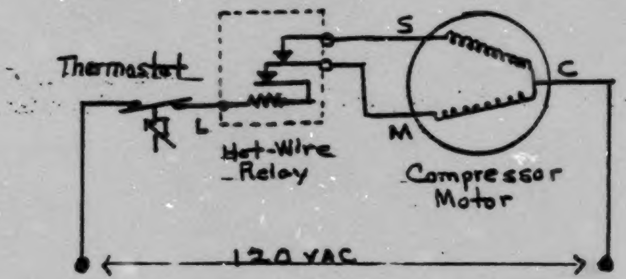
PERFORMANCE OBJECTIVE:

Draw a schematic of a hot-wire relay controlling a compressor motor operated from a 120 VAC line. Show a thermostat between the relay and line. The diagram must agree with the given information and the circuit must operate if constructed.

PERFORMANCE ACTIONS:

12.0401 Draw a schematic of a hot-wire relay controlling a compressor motor. (See sample schematic. Pictorial omitted.)

HOT-WIRE RELAY



PERFORMANCE STANDARDS:

- Draw a schematic of a hot-wire relay controlling a compressor motor operated from a 120 VAC line.
- The circuit must operate if constructed and the schematic must be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify schematic symbol for a hot-wire relay, thermostat, and compressor motor.
- Describe purpose of hot-wire relay.
- Identify typical location of hot-wire relay.

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UNIT 12.0 WIRING DIAGRAMS

TASK 12.05 DRAW A GAS FURNACE WIRING DIAGRAM

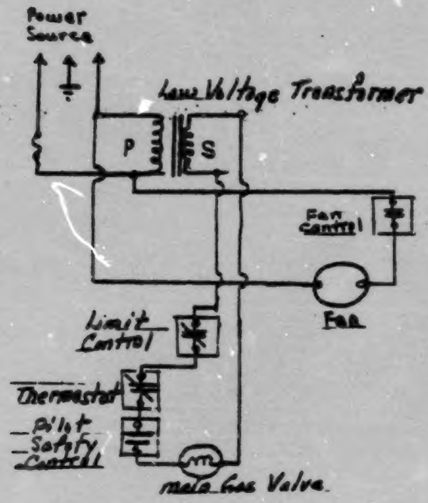
---

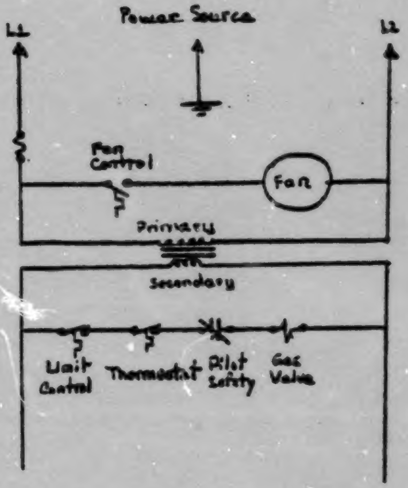
PERFORMANCE OBJECTIVE:

Provided with a gas furnace properly wired, draw a schematic wiring diagram of the furnace using the proper symbols for components. The schematic must match the wiring of the furnace.

PERFORMANCE ACTIONS:

12.0501 Draw a wiring schematic, using proper symbols, of a given gas furnace. (Sample answer below.)


Power Source
Low Voltage Transformer
P
S
Fan Control
Fan
Limit Control
Thermostat
Pilot Safety Control
main Gas Valve


L1
Power Source
L2
Fan Control
Fan
Primary
Secondary
Limit Control
Thermostat
Pilot Safety
Gas Valve

PERFORMANCE STANDARDS:

- Draw a wiring diagram of a given gas furnace.
- The schematic must match the wiring of the furnace and must be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe operation of a gas furnace.
- Identify typical schematic symbols, locate non-typical symbols in reference material.
- Describe operating sequence of a gas furnace.
- Identify safety considerations for a gas fired furnace.

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UNIT 12,0 WIRING DIAGRAMS

TASK 12.06 DRAW AN OUTDOOR CONDENSING UNIT WIRING DIAGRAM

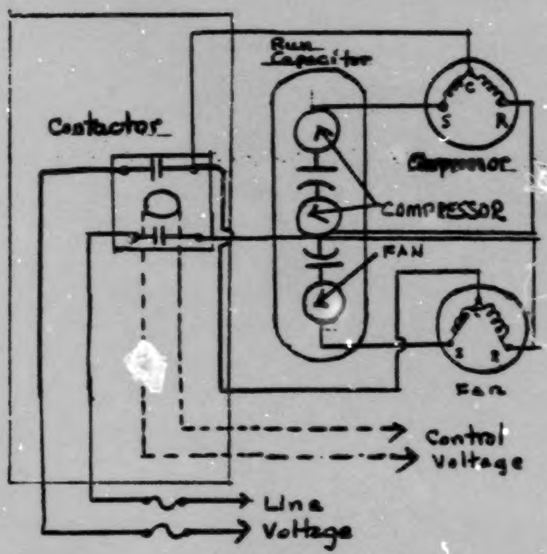
---

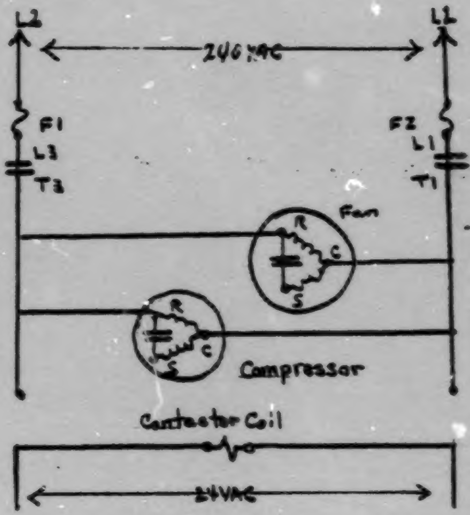
PERFORMANCE OBJECTIVE:

Given an outdoor condensing unit or simulation, draw a schematic of the condensing unit that matches the wiring of the unit.

PERFORMANCE ACTIONS:

12.0601 Draw a wiring schematic of an outdoor condensing unit. (Sample answer below.)


Run Capacitor
Contactor
C
S
R
Compressor
COMPRESSOR
FAN
S
R
Fan
Control
Voltage
Line
Voltage


L2
L1
240 VAC
F1
L2
T2
F2
L1
T1
R
Fan
C
S
R
C
S
Compressor
Contactor Coil
24VAC

PERFORMANCE STANDARDS:

- Draw a schematic of the wiring of given outdoor condensing unit to the instructor's satisfaction.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify typical symbols and locate non-typical symbols in reference material.
- Describe operating sequence of a typical outdoor condensing unit.

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UNIT 12.0 WIRING DIAGRAMS

TASK 12.07 DRAW A WIRING DIAGRAM FOR AN ELECTRIC FURNACE

---

PERFORMANCE OBJECTIVE:

For a given electric furnace, draw a schematic diagram that matches the wiring in the furnace.

PERFORMANCE ACTIONS:

12.0701 Draw a schematic wiring diagram of a given electrical furnace.

PERFORMANCE STANDARDS:

- Draw a schematic diagram of the electrical wiring of a given furnace.
- The diagram must match the circuit of the furnace and must be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe operation of an electric furnace.
- Identify wiring diagram symbols, locate symbols in reference material.
- Describe operating sequence of an electric furnace.

UNIT 12.0 WIRING DIAGRAMS

TASK 12.08 DRAW WIRING DIAGRAM OF SPLIT HEAT AND COOL SYSTEM

---

## PERFORMANCE OBJECTIVE:

Given a sample or description of a split heat and cool system, draw a wiring diagram of the system.

## PERFORMANCE ACTIONS:

12.0801 Draw a wiring schematic for a split heat and cool system.

## PERFORMANCE STANDARDS:

- Draw wiring schematic for a given split heat and cool system.
- The diagram must be acceptable to the instructor and must operate.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Describe the proper application of a split system.
- Identify wiring diagram symbols or located symbols in reference material.
- Describe operating sequence of a typical split system.

UNIT 12.0 WIRING DIAGRAMS

TASK 12.09 DRAW A WIRING DIAGRAM FOR A REFRIGERATOR

---

PERFORMANCE OBJECTIVE:

Given a refrigerator, draw a schematic diagram of the refrigerator wiring. The diagram must match the wiring of the refrigerator.

PERFORMANCE ACTIONS:

12.0901 Draw wiring schematic for a refrigerator.

PERFORMANCE STANDARDS:

- Draw a schematic diagram that matches the wiring of a given refrigerator.
- The diagram must be acceptable to the instructor and must represent the given appliance.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain operating sequence for refrigerator.
- Identify schematic symbols for refrigerator wiring.
- Demonstrate proper use of schematic symbols.

UNIT 12.0 WIRING DIAGRAMS

TASK 12.10 DRAW A LADDER WIRING DIAGRAM OF A WINDOW AIR CONDITIONER

---

---

PERFORMANCE OBJECTIVE:

Provided with a window air conditioner, draw a ladder schematic wiring diagram that matches the wiring of the unit.

PERFORMANCE ACTIONS:

12.1001 Draw a ladder wiring diagram of a window air conditioner.

PERFORMANCE STANDARDS:

- For a given window air conditioner, draw a ladder schematic wiring diagram that matches the unit.
- The diagram must be acceptable to the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe the operation and characteristics of a window air conditioner.
- Identify or locate schematic symbols for a window air conditioner.
- Describe the operating sequence of a window air conditioner.

UNIT 12.0 WIRING DIAGRAMS

TASK 12.11 DRAW SCHEMATIC WIRING DIAGRAM OF LOW VOLTAGE CONTROL CIRCUIT

---

PERFORMANCE OBJECTIVE:

Provided with an actual, simulated, or description of a low voltage control system, draw a schematic diagram that accurately represents the low voltage system.

PERFORMANCE ACTIONS:

12.1101 Draw a schematic wiring diagram of a low voltage control system.

PERFORMANCE STANDARDS:

- Draw an accurate schematic wiring diagram of a given low voltage control system.
- The diagram must be acceptable to the instructor and must operate if constructed.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify typical symbols of components found in low voltage circuits.
- Describe operating sequence of a typical low voltage control circuit.
- Identify typical components used in low voltage control systems.

# UNIT 13.0

# ELECTRICAL COMPONENTS

For information concerning capacitors used in control and motor circuits, see the previous unit concerning electrical fundamentals.

# HVAC
# ELECTRICAL COMPONENTS
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | | SUGGESTED HOURS |
|---|---|---|---|
| Unit | 13.0 | ELECTRICAL COMPONENTS | |
| | 13.01 | Install a Single Stage Heat and Single Stage Cool Thermostat | * |
| | 13.02 | Wire a Hot Wire Relay | * |
| | 13.03 | Wire a Current Relay | * |
| | 13.04 | Wire a Potential (Voltage) Relay | * |
| | 13.05 | Wire a Fan Relay | * |
| | 13.06 | Measure Voltage to Relay Coil | * |
| | 13.07 | Make Resistance Measurements of a Relay Coil and Contact Points | * |
| | 13.08 | Test Starter Relay with Ammeter | * |
| | 13.09 | Wire a Time Delay Relay | * |
| | 13.10 | Wire/Replace Contactor or Starter | * |
| | 13.11 | Adjust Low Pressure Control | * |
| | 13.12 | Adjust High Pressure Control | * |
| | 13,13 | Adjust Oil Pressure Switch | * |
| | 13,14 | Install and Test a Magnetic Overload | * |
| | 13.15 | Install Thermal Overload | * |
| | 13.16 | Replace Low Voltage (Control) Transformer | * |
| | 13.17 | Connect Capacitor Timing Starter (OPTIONAL) | * |
| | 13.18 | Construct a Basic SCR Speed Control Circuit (OPTIONAL) | * |

| | | |
|---|---|---|
| 13.19 | Install Solid State Relay in Circuit (OPTIONAL) | * |
| 13.20 | Troubleshoot Controls | * |
| | TOTAL HOURS | 15 |

* - Total Time Estimated

# TASK LISTINGS
# HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 13.0 | ELECTRICAL COMPONENTS |
| 13.01 | (INSTALL A SINGLE STAGE HEAT AND SINGLE STAGE COOL THERMOSTAT) Given a heating and cooling system, a thermostat, and the necessary tools, wire, and other materials required; install the thermostat so that it is in retyn air stream, level, 60 inches from the floor. Both stages of the system must cycle load on and off, within several degrees of the desired setting. |
| 13.02 | (WIRE A HOT WIRE RELAY) Provided with a refrigerator wire a hot wire relay, wire the relay so that it removes the start winding at about 75 percent of motor speed. The wires will be mechanically and electrically secure. |
| 13.03 | (WIRE A CURRENT RELAY) Provided with an electrical system with a current relay, wire the relay so that it drops out the start winding when the motor reaches 75 percent of renning speed. The wires must be mechanically and electrically secure and, if a directional relay is used, the relay will be in the upright position. |
| 13.04 | (WIRE A POTENTIAL /VOLTAGE/ RELAY) Given a refrigeration electrical system and a potential (voltage) relay, wire the relay so that it drops out of the start winding when the motor reaches 75 percent of running speed. The wires must be mechanically and electrically secure. |
| 13.05 | (WIRE A FAN RELAY) Given a HVAC unit equipped with a fan relay, necessary tools and supplies, and replacement fan (or remove and replace); wire a fan relay according to the wiring diagram. The relay must safely start and run the motor. Wiring must be mechanically and electrically secure. |
| 13.06 | (MEASURE VOLTAGE TO RELAY COIL) Provided with several types of HVAC relays and a VOM, measure the voltage to the relay coils. Measurements must be within 10 percent of the instructor's predetermined measurements. |
| 13.07 | (MAKE RESISTANCE MEASUREMENTS OF A RELAY COIL AND CONTACT POINTS) Given several different types of relays, the VOM or ohmmeter scale of the Amprobe; measure the resistance of the relay coil and contact points of each realy. Readings should be within 10 percent of predetermined values. |

13.08 (TEST STARTER RELAY WITH AMMETER) Provided with a clamp-on ammeter, a range multiplier or wire to make a loop multiplier if needed, and several different types of start relays; test the relays with the ammeter. After starting, the amperage reading of the start winding should be zero.

13.09 (WIRE A TIME DELAY RELAY) Given a HVAC electrical circuit equipped with a time delay realy, diagram/schematic, necessary tools and materials; wire the relay according to the diagram. The relay must operate properly within given time ranges.

13.10 (WIRE/REPALCE CONTACTOR OR STARTER) Given a HVAC system equipped with a contactor or starter, power source, wire, and the necessary tools and materials and replacement parts; wire contactor or starter according to given system wiring diagram/schematic. The contactor/starter must safely start and stop the system and all wire leads must be mechanically and electrically secure.

13.11 (ADJUST LOW PRESSURE CONTROL) Given a refrigeration system with a low pressure control, gauges and manifold set and a means of simulating a blocked evaporator air flow, adjust the low pressure ocntrol so that it shuts the system sown if the suction pressure drops below predetermined value.

13.12 (ADJUST HIGH PRESSURE CONTROL) Provided with a refrigeration system with a high pressure control, gauge and manifold set, and means of blocking the air flow across the condenser and the necessary tools and materials; adjust the high pressure control so that it shut down the system if the head pressure rises above a predetermined value.

13.13 (ADJUST OIL PRESSURE SWITCH) Given an operating system equipped with an oil pressure switch, power source, gagues, and necessary tools and materials; adjust the oil pressure switch so that it will stop the compressor if the oil pressure drops to suction plus psi.

13.14 (INSTALL AND TEST A MAGNETIC OVERLOAD) Provided with an operational three-phase compressor, contactor, power source, overloads, wire, necessary tools and materials; install a magnetic overlaod. The magnetic overload must safely open control circuit under overload conditions. Test operation of overload.

13.15 (INSTALL THERMAL OVERLOAD) Given a functional single-phase compressor, power source, thermal overload, wire, and necessary tools and materials; install the thermal overload according to the manufacturer's wiring diagram. The thermal overload must safely open the control circuit under temperature and current overload.

13.16 (REPLACE LOW VOLTAGE /CONTROL/ TRANSFORMER) Provided with a HVAC system using a low voltage (control) transformer, remove and replace the transformer. The transformer must be mounted properly in the circuit mechanically and electrically secure, and wired according to the manufacturer's diagram.

13.17 (CONNECT CAPACITOR TIMING STARTER) Given a capacitor timing starter, line contactor, the necessary tools and materials, connectors and conductors; connect a capacitor timing starter. The capacitor timing starter will hold the line contactor closed for a period of time after the switch has been pushed.

13.18 (CONSTRUCT A BASIC SCR SPEED CONTROL CIRCUIT) Given a schematic diagram of a SCR speed control circuit, components, components list, motor or other device to be controlled, VOM, and the necessary tools and materials; construct a SCR spped control circuit. Circuit construction will be according to schematic diagram provided, components and wiring must be mechanically and electrically secrue, and the control circuit must operate or control another device as intended.

13.19 (INSTALL SOLID STATE RELAY IN CIRCUIT) Given a requirement for a solid state relay, solid state relay, relay specifications, and all necessary tools and materials; install a solid state control relay. The solid state relay must be selected and connected so that it functions properly.

13.20 (TROUBLESHOOT CONTROLS) Given possibly defective controls, necessary references, VOM clamp-on amprobe, required tools and equipment; troubleshoot the control circuit and control devices to identify repair(s) needed or if controls should be replaced. Repaired circuits should operate as intended. Performance must be within given time and meet the instructor's standards.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.01 INSTALL A SINGLE STAGE HEAT AND SINGLE STAGE COOL THERMOSTAT

## PERFORMANCE OBJECTIVE:

Given a heating and cooling system, a thermostat, and the necessary tools, wire, and other materials required; install the thermostat so that it is in the return air stream, level, 60 inches from the floor. Both stages of the system must cycle load on and off, within several degrees of the desired setting.

## PERFORMANCE ACTIONS:

13.0101 Disconnect power source.

13.0102 Remove cover from control.

13.0103 Remove mounting screws from control (or box).

13.0104 Disconnect electrical wires from control subbase (make sketch of wiring if no diagram available).

13.0105 Remove subbase from wall (Normally in field discard old unit.) (Classroom training will reuse unit,)

13.0106 Mount new control subbase.

13.0107 Level base.

13.0108 Connect electrical wires to subbase following sketch or wiring diagram.

13.0109 Mount new control on subbase.

13.0110 Replace cover.

13.0111 Restore power.

13.0112 Start unit and check operation.

## PERFORMANCE STANDARDS:

- Install a single stage heat and single stage cool thermostat that is in the return air stream, level, 60 inches from the floor and that causes both stages of the system to cycle load on and off, within several degrees of the desired setting.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.02 INSTALL A SINGLE STAGE HEAT AND SINGLE STAGE COOL THERMOSTAT (Con't.)

---

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Basic construction and operation of the thermostat.
- Describe operation of two stage heat and two stage cool thermostat.
- Describe an application for a two stage heat and two stage cool thermostat.
- Identify major functions of a temperature control.
- Manufacturer's instructions.
- Identify safety considerations.

## UNIT 13.0 ELECTRICAL COMPONENTS

## TASK 13.02 WIRE A HOT WIRE RELAY

---

PERFORMANCE OBJECTIVE:

Provided with a refrigerator with a hot wire relay, with the relay so that it removes the start winding at about 75 percent of motor speed. The wires will be mechanically and electrically secure.

PERFORMANCE ACTIONS:

13.0201 Locate wiring diagram or make diagram of circuit.

13.0202 Disconnect power.

13.0203 Locate relay (if old one being removed).

13.0204 Remove wires from relay.

13.0205 Remove relay.

13.0206 Position new relay.

13.0207 Make electrical connections.

13.0208 Connect unit to power source.

13.0209 Start unit.

13.0210 Test amperage draw (TEST HOT WIRE RELAY):
a. Diconnect power.
b. Remove wries from relay.
c. Test for zero ohms resistance across L to M terminals using ohmmeter.
d. Connect wires.
e. Restore power.
f. Test run: Relay must remove start winding from circuit at 75-80 percent of full running speed.

PERFORMANCE STANDARDS:

- Wire a hot wire relay so that it removes the start winding at about 75 percent of motor speed and so the wires are mechanically and electrically secure.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain the purpose of a hot wire relay.
- Identify the typical location of a hot wire relay.
- Describe how to determine if the start winding has dripped out.
- Describe how to install wire leads and terminals.
- Demonstrate how to read a schematic or wiring diagram.
- Manufacturer's specifications.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.03 WIRE A CURRENT RELAY

---

## PERFORMANCE OBJECTIVE:

Provided with an electrical system with a current relay, wire the relay so that it drops out the start winding when the motor reaches 75 percent of running speed. The wires must be mechanically and electrically secure and, if a directional relay is used, the relay will be in the upright position.

## PERFORMANCE ACTIONS:

13.0301 Disconnect power.

13.0302 Remove terminal cover.

13.0303 Remove relay from terminals.

13.0304 Remove wires from relays.

13.0305 Install replacement relay.*

13.0306 Wire replacement relay.

13.0307 Connect power.

13.0308 Check operation of unit, amperage draw, etc., stop unit.

13.0309 Replace covers, etc.

## PERFORMANCE STANDARDS:

- Wire a current relay so that the start winding drops out when the motor reaches 75 percent of running speed.
- The wires must be mechanically and electrically secure and the relay must be in the upright position (if directional relay).

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Explain purpose of current (coil) relays.
- Identify typical location of current relays.
- Describe how to determine if the start winding has dropped out.

*Solid state relay may be used for replacement.
  - Explain fundamental design of solid state relay.
  - Explain principle of solid state relay.
  - Review manufacturer;s instruction sheet on relay.
  - Identify considerations in using solid state realys.

RELATED TECHNICAL INFORMATION (Con't.):

- Describe how to install wiring: Typical wiring
    a. Live voltage to "L" on relay.
    b. Start terminal lead to "S" on relay.
    c. Run terminal lead to "M" on relay.
    d. Remaining wire to compressor motor external overload.
- Describe/demonstrate how to install wire terminals.
- Read a schematic showing the installation of a current relay.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.04 WIRE A POTENTIAL (VOLTAGE) RELAY

---

PERFORMANCE OBJECTIVE:

Given a refrigeration electrical system and a potential (voltage) relay, wire the relay so that it drops out of the start winding when the motor reaches 75 percent of running speed. The wires must be mechanically and electrically secure.

PERFORMANCE ACTIONS:

13.0401 Disconnect power.

13.0402 Locate relay.

13.0403 Remove wires from relay.

13.0404 Remove relay.

13.0405 Position replacement relay.

13.0406 Connect wires to relay following manufacturer's diagram or schematic.

13.0407 Connect power.

13.0408 Start unit.

13.0409 Check relay for proper operation:

a. Check wiring diagram.
b. Clamp ammeter around start capacitor wire.
c. Connect electrical power.
d. Start system.
e. Check length of time for starting circuit to disengage (Remove electrical power if starting circuit does not disengage immediately).
f. Check full load amperage.
g. Remove ammeter.
h. Stop system.

PERFORMANCE STANDARDS:

- Wire a potential (voltage) relay so that the motor start winding drops out when 75 percent of running speed is reached.
- Wires must be mechanically and electrically secure.

---

SUGGESTED INSTRUCTION TIME:

*Proper operation is when resistance of contact points to voltage is sufficiently high to prevent the points from opening before the motor reaches 80-90 percent of its full speed and low enough to positively open the points and remove the starting winding from the circuit. Any deviation from this specified performance must be detected.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.05 WIRE A FAN RELAY

---

PERFORMANCE OBJECTIVE:

Given a HVAC unit equipped with a fan relay, necessary tools and supplies, and replacement fan (or remove and replace); wire a fan relay according to the wiring diagram. The relay must safely start and run the motor. Wiring must be mechanically and electrically secure.

PERFORMANCE ACTIONS:

13.0501 Disconnect power.

13.0502 Locate the relay.

13.0503 Remove the electrical leads to the relay.

13.0504 Remove the relay.

13.0505 Position the replacement relay.

13.0506 Connect the electrical wires to the relay according to the manufacturer's diagram/schematic.

13.0507 Connect the power.

13.0508 Start the unit.

13.0509 Check the relay for proper operation.

PERFORMANCE STANDARDS:

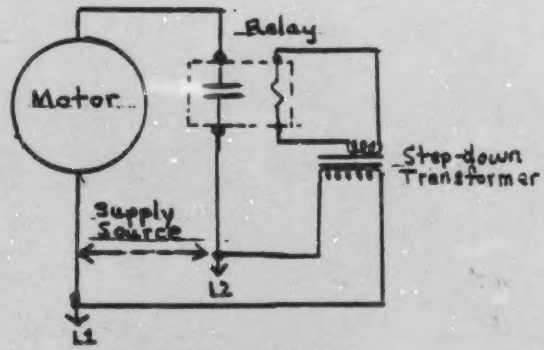
- Wire a fan relay with wiring that is mechanically and electrically secure and according to the manufacturer's specifications and so the fan operates properly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe the operation of a fan relay.
- Explain the purpose/functions of the fan relay.
- Identify types of relays typically used as fan relays.
- Identify typical locations for the relays.
- Identify safety considerations.

SAMPLE CIRCUIT ON ADDENDUM PAGE


Relay
Motor
Step-down Transformer
Supply Source
L2
L1

FAN RELAY

BEST COPY AVAILABLE

UNIT 11.0 ELECTRICAL WIRE CONNECTIONS

TASK 11.04 (Optional) SOLDER ELECTRICAL CONDUCTORS AND CONNECTIONS

---

## PERFORMANCE OBJECTIVE:

Given tools, equipment, and materials including a soldering gun/iron and electrical solder and wiring or electrical connections to solder; solder the electrical wires or terminals so that a tight mechanical and electrical bond is formed.

## PERFORMANCE ACTIONS:

11.0401 Assemble tools, equipment, and materials.

11.0402 Identify wires, terminals, etc., to be soldered.

11.0403 Remove about 1/4 inch (or appropriate length) insulation from wires and clean wires being careful not to cut them.

11.0404 Twist wires together to form a united conductor (Wire may be thinned to promote soldering to connectors, etc.).

- a. Splice two wires together.
- b. Connect wire to terminal.
- c. Connect component to terminal.

11.0405 Solder mechanical/electrical connection allowing solder to flow on heated joint.

11.0406 Allow solder to cool.

11.0407 Check connection.

11.0408 Clean and tape joint tightly with two or more layers of recognized electrical tape to ensure that no electrical hazard is exposed. (Use heat shrink tubing or tape, if required/recommended.)

## PERFORMANCE STANDARDS:

- Solder given electrical conductors and connections using proper solder and soldering methods/techniques so that the soldered connections are mechanically and electrically bonded together.

## SUGGESTED INSTRUCTION TIME:

TASK 13.06 MEASURE VOLTAGE TO RELAY COIL

---

PERFORMANCE OBJECTIVE:

Provided with several types of HVAC relays and a VOM, measure the voltage to the relay coils. Measurements must be within 10 percent of the instructor's predetermined measurements.

PERFORMANCE ACTIONS:

13.0601 Identify/locate voltage relays to be measured.

13.0602 Set VOM to proper voltage scale and range.

13.0603 Identify terminals on relay that expose voltage source.

13.0604 Apply power.

13.0605 Using care not to contact any voltage exposed in the test area with the body, apply the test probes to the proper points and read the voltage. (If the range is in question, start at the highest range and work down to obtain the most accurate voltage measurement.)

13.0606 Remove the VOM and disconnect power.

PERFORMANCE STANDARDS:

- Measure the voltage applied to a relay coil.
- The measured voltage must be within 10 percent of a predetermined value identified by the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Determine the coil voltage.
- Know typical coil voltages for relays used in HVAC systems.
- Describe how to set up the VOM for voltage measurements.
- Describe procedures/techniques for measuring voltage to a relay coil.
- Identify personal and equipment safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.07 MAKE RESISTANCE MEASUREMENTS OF A RELAY COIL AND CONTACT POINTS

---

## PERFORMANCE OBJECTIVE:

Given several different types of relays, the VOM or ohmmeter scale of the Amprobe; measure the resistance of the relay coil and contact points of each relay. Readings should be within 10 percent of predetermined values.

## PERFORMANCE ACTIONS:

13.0701 Assemble ohmmeter instrument (VOM, ohmeter scale of Amprobe, etc.).

13.0702 Identify relay to be tested.

13.0703 Remove power from relay (Coil and points to be tested.).

13.0704 Check coil for continuity, resistance if known.

13.0705 Replace coil if open.

13.0706 Check contact points for continuity.

13.0707 If poor continuity, clean contact points or replace.

13.0708 Apply power, test relay operation.

## PERFORMANCE STANDARDS:

- Make resistance measurements of relay coil and contact points with readings that are within 10 percent of the instructor's predetermined readings.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Explain what is a resistance reading.
- Describe how to use the ohmmeter.
- Explain the purpose of a relay.
- Explain how the relay works.
- Describe why different types of relays have different sizes of wire and resistance values.
- Explain why the contact points may vary in resistance.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.08 TEST STARTER RELAY WITH AMMETER

---

PERFORMANCE OBJECTIVE:

Provided with a clamp-on ammeter, a range multiplier or wire to make a loop multiplier if needed, and several different types of start relays; test the relays with the ammeter. After starting, the amperage reading of the start winding should be zero.

PERFORMANCE ACTIONS:

13.0801 Identify start relays to be tested.

13.0802 Assemble ammeter, set proper scale, assemble range multiplier accessory or use/construct field expedient multiplier as needed.

13.0803 Following safe practices, use ammeter to observe current drawn by relay.

PERFORMANCE STANDARDS:

- Test start relay with ammeter, observing current drawn and noting that current falls to zero after motor is started.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe characteristics of different start relays.
- Explain operation of clamp-on ammeter.
- Explain operation/use of ammeter multiplier (Describe how to construct multiplier for ammeter in the field using wire).
- Differentiate that starting current will be 5-6 times higher than running current.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.09 WIRE A TIME DELAY RELAY

---

PERFORMANCE OBJECTIVE:

Given a HVAC electrical circuit equipped with a time delay relay, diagram/schematic, necessary tools and materials; wire the relay according to the diagram. The relay must operate properly within given time ranges.

(Task may be revised to replace a time delay relay.)

PERFORMANCE ACTIONS:

13.0901 Disconnect power.

13.0902 Remove service cover.

13.0903 Identify relay location.

13.0904 If existing relay is in place, remove wires, and remove relay.

13.0905 Mount new relay.

13.0906 Install wiring on relay according to wiring diagram or manufacturer's schematic.

13.0907 Connect unit to power source.

13.0908 Start machine.

13.0909 Test relay.

13.0910 Stop machine, replace service cover.

PERFORMANCE STANDARDS:

- Wire or replace a time delay relay according to manufacturer's wiring specifications and test to be sure the relay operates properly within given time ranges.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how a time relay operates.
- Explain why a time delay is used.
- Describe some different types of time delay relays.
- Explain what is a lock-out relay.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.10 WIRE/REPLACE CONTACTOR OR STARTER

---

PERFORMANCE OBJECTIVE:

Given a HVAC system equipped with a contactor or starter, power source, wire, and the necessary tools and materials and replacement parts; wire contactor or starter according to given system wiring diagram/schematic. The contactor/starter must safely start and stop the system and all wire leads must be mechanically and electrically secure.

PERFORMANCE ACTIONS:

13.1001 Disconnect power, remove service panel.

13.1002 Remove wire leads from contactor relay (if unit being replaced).

13.1003 Remove contactor relay.

13.1004 Replace contactor relay with one of same electrical specifications.

13.1005 Rewire contactor relay.

13.1006 Connect power.

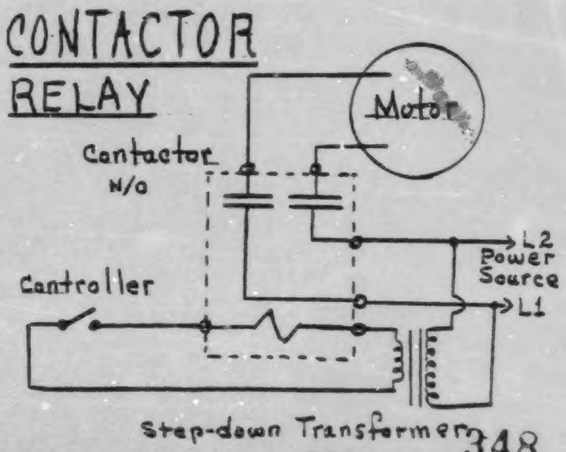
13.1007 Start unit.

13.1008 Test amperage draw, observe operation.

13.1009 Stop unit.

13.1010 Replace service panel.

(SAMPLE WIRING DIAGRAM)



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TASK EXPANSION:

Test magnetic contactor with ohmmeter. The ohmmeter should measure zero ohms with open contacts and infinity with contacts closed on N/O relay.

-Disconnect power.

-Disconnect electrical leads.

-Connect ohmmeter to contacts being tested.

-Apply test voltage to relay coil, observe condition of relay.

-Remove ohmmeter and test voltage.

-Reconnect electrical leads.

-Restore power.

-Start unit.

PERFORMANCE STANDARDS:

- Wire/replace magnetic contactor or starter relay.
- Amature must not bind and must move freely.
- Unit must start and stop properly.
- Electrical leads must be mechanically and electrically secure.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe operation of magnetic contactor or starter.
- Identify typical HVAC applications of contactor or starter.
- Identify contactor and starter symbols.
- Describe how to test amperage or contactor or starter.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.11 ADJUST HIGH PRESSURE CONTROL

---

## PERFORMANCE OBJECTIVE:

Provided with a refrigeration system with a high pressure control, gauge and manifold set, and means of blocking the air flow across the condenser and the necessary tools and materials; adjust the high pressure control so that it shuts down the system if the head pressure rises above a predetermined value.

(NOTE: If control is of dual pressure type, see following task.)

## PERFORMANCE ACTIONS:

13.1101 Attach gauges on high side and low side.

13.1102 Start system and allow time for pressure to stabilize.

13.1103 Remove cover on high pressure control.

13.1104 Simulate a rise in the head pressure.

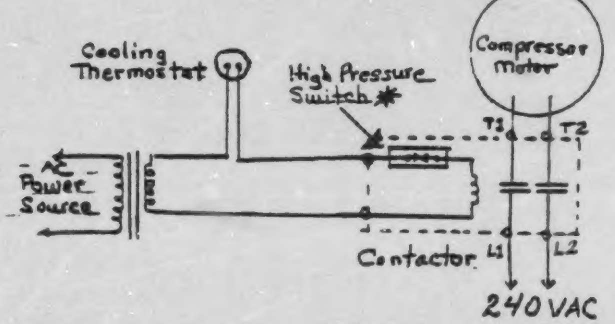
13.1105 Adjust high pressure so system control shuts down system at predetermine value (manufacturer's specifications).

13.1106 Replace cover, remove gauges, replace caps on gauge parts.

13.1107 Test for leaks.

(SAMPLE WIRING DIAGRAM)

HIGH PRESSURE SWITCH



* Note: Low pressure switch may be substituted to represent "Low pressure switch" system.

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PERFORMANCE STANDARDS:

- Adjust high pressure control so that it shuts down the system if the head pressure rises above a predetermined value.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain purpose of high pressure control.
- Describe types of controls.
- Describe how to simulate a high pressure condition.
- Explain how to attach and read gauges.
- Explain how to determine correct setting of high pressure controls.
- Explain range and differential.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.12 ADJUST LOW PRESSURE CONTROL

---

PERFORMANCE OBJECTIVE:

Given a refrigeration system with a low pressure control, gauges and manifold set and a means of simulating a blocked evaporator air flow, adjust the low pressure control so that it shuts the system down if the suction pressure drops below a predetermined value.

(NOTE: If control is of dual pressure type, see previous task.)

PERFORMANCE ACTIONS:

13.1201 Attach gauges on high and low side.

13.1202 Start system and allow time for pressure to stabilize.

13.1203 Remove cover on low pressure control.

13.1204 Simulate blocked evaporator air flow.

13.1205 Adjust low pressure so that it shuts the system down if the suction pressure drops below a predetermined value (manufacturer's specifications).

13.1206 Replace cover, remove gauges, replace caps on gauge ports.

13.1207 Test for leaks.

PERFORMANCE STANDARDS:

- Adjust low pressure control so that it shuts the system down if the suction pressure drops below a predetermined value.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain purpose of low pressure control.
- Describe various types of low pressure controls.
- Describe how to simulate improper air flow across an evaporator.
- Describe/demonstrate how to attach and read gauges.
- Explain how to determine correct settings.
- Explain range and differential.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.13 ADJUST OIL PRESSURE SWITCH

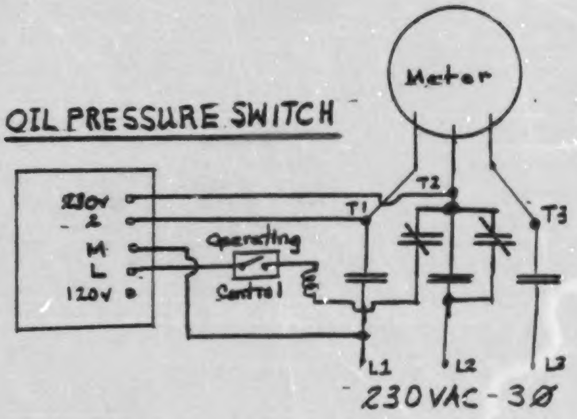
---

PERFORMANCE OBJECTIVE:

Given an operating system equipped with an oil pressure switch, power source, gauges, and necessary tools and materials; adjust the oil pressure switch so that it will stop the compressor if the oil pressure drops to suction plus psi.

PERFORMANCE ACTIONS: (Instructor to clarify actions or see manufacturer's service manual.)

(SAMPLE WIRING DIAGRAM)


OIL PRESSURE SWITCH
Meter
230v
2
M
L
120v
Operating
Control
T1
T2
T3
L1
L2
L3
230VAC-3Ø

PERFORMANCE STANDARDS:

- Adjust oil pressure switch so that it will stop the compressor if the oil pressure drops to suction plus psi.

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UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.13 ADJUST OIL PRESSURE SWITCH (Con't.)

---

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe operation of an oil pressure switch.
- Locate an oil pressure switch specified by the compressor manufacturer.
- Identify location within the system circuit.
- Describe/identify different types of oil pressure switches.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.14 INSTALL AND TEST A MAGNETIC OVERLOAD

---

PERFORMANCE OBJECTIVE:

Provided with an operational three-phase compressor, ocntactor, power source, overloads, wire, necessary tools and materials; install a magnetic overload. The magneitc overload must safely open control circuit under overload conditions. Test operation of overload.

PERFORMANCE ACTIONS:

13.1401 Disconnect power.

13.1402 Remove cover plate.

13.1403 Locate magnetic overload to be removed, if applicable.

13.1404 Remove wiring.

13.1405 Remove magnetic overload.

13.1406 Replace device with new overlaod.

13.1407 Replace wiring.

13.1408 Restore power.

13.1409 Start system, check operation.

13.1410 TO TEST OVERLOAD:

1. Check current draw with ammeter or on nomeclature plate.
2. Compare current draw with rating of overload device to determine proper rating.

PERFORMANCE STANDARDS:

- Install a magnetic overload that safely opens the control circuit under overload conditions.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe the operation of a magnetic overload.
- Identify/describe where magnetic overloads typically are employed.
- Identify other types of overload devices.
- Identify possible locations for overload devices in given circuits.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.15 INSTALL THERMAL OVERLOAD

---

## PERFORMANCE OBJECTIVE:

Given a functional single-phase compressor, power source, thermal overload, wire, and necessary tools and materials; install the thermal overload according to the manufacturer's wiring diagram. The thermal overload must safely open the control circuit under temperature and current overload.

## PERFORMANCE ACTIONS:

13.1501 Disconnect power.

13.1502 Remove cover plate.

13.1503 Locate thermal overload to be removed or tested.

13.1504 Remove wiring.

13.1505 Remove overload.

13.1506 Replace device.

13.1507 Replace wiring.

13.1508 Restore power.

13.1509 Start system, check operation.

## PERFORMANCE STANDARDS:

- Install thermal overload device that will safely open the control circuit under temperature and current overload.

SUGGESTED INSTRUCTION TIME: Hours

## RELATED TECHNICAL INFORMATION:

- Describe operation of thermal overload.
- Explain uses of thermal overload.
- Describe types of thermal overloads.
- Identify typical overload locations in circuits.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.16 REPLACE LOW VOLTAGE (CONTROL) TRANSFORMER

---

PERFORMANCE OBJECTIVE:

Provided with a HVAC system using a low voltage (control) transformer, basic tools and materials, and replacement transformer; remove and replace the transformer. The transformer must be mounted properly in the circuit, mechanically and electrically secure, and wired according to the manufacturer's diagram.

PERFORMANCE ACTIONS:

13.1601 Determine if transformer is faulty: Open, shorted, or grounded.

13.1602 Disconnect power.

13.1603 Locate transformer to be removed.

13.1604 Remove electrical leads.

13.1605 Mechanically remove transformer.

13.1606 Connect leads with correct primary and secondary wiring.

13.1607 Restore power.

13.1608 Check low voltage control circuit operation.

PERFORMANCE STANDARDS:

- Replace low voltage transformer in given system so that the transformer is mounted mechanically secure with correct electrical connections that provice the desired control voltage according to manufacturer's specifications.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe what a low voltage transformer does.
- Identify typical applications of low voltage control circuits.
- Describe how to use the voltmeter and ohmmeter to test a low voltage transformer.
- Describe how to distinguish primary and secondary windings.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.17 CONNECT CAPACITOR TIMING STARTER

---

PERFORMANCE OBJECTIVE:

Given a capacitor timing starter, line contactor, the necessary tools, materials, connectors and conductors; connect a capacitor timing starter. The capacitor timing starter will hold the line contactor closed for a period of time after the switch has been pushed.

PERFORMANCE ACTIONS:

13.1701 Connect capactior timing starter.

PERFORMANCE STANDARDS:

- Connect capacitor riming starter that will hold the line contactor closed for a period of time after the switch has been pushed.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain what determines the time period for a contactor to remain closed.
- Describe principle of capacitor timing.
- Explain how the capacitor timing principle is applied to an electromagnetic starter.
- Identify safety considerations.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.18 CONSTRUCT A BASIC SCR SPEED CONTROL CIRCUIT

---

PERFORMANCE OBJECTIVE:

Given a schematic diagrma of a SCR speed control circuit, components, components list, motor or ther device to be controlled, VOM, and the necessary tools and materials; construct a SCR speed control circuit. Circuit construction will be according to schematic diagram provided, components and wiring must be mechanically and electrically secure, and the control cirucit must operate or control another device as intended.

PERFORMANCE ACTIONS:

13.1801 Review drawing, schematic, etc.

13.1802 Assemble materials.

13.1803 Construct circuit according to schematic.

13.1804 Check circuit wiring.

13.1805 Apply voltage and test circuit operation.

13.1806 Test circuit control of device (operate as intended, to specifications).

PERFORMANCE STANDARS:

- Construct a basic SCR speed control circuit according to schematic diagram with mechanically and electrically secure connections and so the control device operates as intended.
- Performance process and product must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain why a basic SCR speed control offers only limited control.
- Explain why a neon lamp is used in a basic SCR speed control circuit.
- Describe the operation of a SCR speed control circuit.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.19 INSTALL SOLID STATE RELAY IN CIRCUIT

---

PERFORMANCE OBJECTIVE:

Given a requirement of a solid state relay, solid state relay, relay specifications, and all necessary tools and materials; install the solid state control relay. The solid state relay must be selected and connected so that it properly functions.

PERFORMANCE ACTIONS:

13.1901 Review circuit drawing and requirements for solid state relay device(s).

13.1902 Select or check relay provided to ensure that it will properly operate in the circuit.

13.1903 Wire the relay in the circuit.

13.1904 Test the circuit for proper operation.

PERFORMANCE STANDARDS:

- Install solid state relay in cirucit sccording to requirements so that it functions properly.
- Performance must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Construction of solid state relays.
- Characteristics of solid state relays.

UNIT 13.0 ELECTRICAL COMPONENTS

TASK 13.20 TROUBLESHOOT CONTROLS

---

## PERFORMANCE OBJECTIVE:

Given possibly defective controls, necessary references, VOM clamp-on amprobe, required tools and equipemnt; troubleshoot the control cirucit and control devices to identify repair(s) needed or if controls should be replaced. Repaired circuits should operate as intended. Performance must be within given time and meet instructors standards.

## PERFORMANCE ACTIONS:

13.2001 Follow standard or recommended troubleshooting procedures. (See accompanying "Motor Control Trouble-Remedy Guide.")

13.2002 Observe safety.

## PERFORMANCE STANDARDS:

- Troubleshoot controls, identifying repair(s) needed and replacement situations.
- If required, make repairs or replacements so that controls operate as intended.
- Performance must be to the instructor's standards.

## SUGGESTED INSTRUCTION TIME:

## REALTED TECHNICAL INFORMATION:

- Identify typical control devices in current use.
- Describe how different control devices function.
- Interpret or draw required control circuits.
- Classify control problems by symptoms usch as contact chatter, welding or freezing, overheating, etc.

Addendum to Task 13.20

## MOTOR CONTROL TROUBLE-REMEDY GUIDE
(Magnetic Contactors and Starters)

| SYMPTOMS | PROBABLE CAUSE | RECOMMENDED ACTION |
|---|---|---|
| CONTACTS | | |
| Contact Chatter | 1. Broken shading coil. | 1. Replace magnet and armature. |
| | 2. Poor contact in control circuit. | 2. Replace the contact device or use holding circuit interlock (3 wire control). |
| | 3. Low voltage. | 3. Correct voltage condition. Check momentary voltage dip during starting. |
| Welding or Freezing | 1. Abnormal inrush of current. | 1. Check for grounds, shorts or excessive motor load current or use larger contactor. |
| | 2. Rapid jogging. | 2. Install larger device rated for jogging service. |
| | 3. Insufficient tip pressure. | 3. Replace contacts and springs, check contact carrier for deformation or damage. |
| | 4. Low voltage preventing magnet from sealing. | 4. Correct voltage condition. Check momentary voltage dip during starting. |
| | 5. Foreign matter preventing contacts from closing. | 5. Clean contacts with Freon. Contactors, starters, and control accessories used with very small current or low voltage, should be cleaned with Freon. |
| | 6. Short circuit. | 6. Remove short or fault and check to be sure fuse or breaker size is correct. |
| Short Tip Life or Overheating of Tips | 1. Filing or dressing. | 1. Do not file silver tips. Rough spots or discoloration will not harm tips or impair their efficiency. |
| | 2. Interrupting excessively high currents. | 2. Install larger device or check for grounds, shorts or excessive motor currents. |
| | 3. Excessive jogging. | 3. Install larger device rated for jogging. |
| | 4. Weak tip pressure. | 4. Replace contacts and springs, check contact carrier for deformation or damage. |
| | 5. Dirt or foreign matter on contact surface. | 5. Clean contacts with Freon. |
| | 6. Short circuits. | 6. Remove short or fault and check to be sure fuse or breaker size is correct. |
| | 7. Loosen connection. | 7. Clean and tighten. |
| | 8. Sustained overload. | 8. Check for excessive motor load current or install larger device. |

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| | | |
|---|---|---|
| COILS | | |
| Open Circuit | 1. Mechanical damage. | 1. Handle and store coils carefully. |
| Roasted Coil | 1. Over voltage or high ambient temperature. | 1. Check application, circuit, and correct. |
| | 2. Incorrect oil. | 2. Install correct coil. |
| | 3. Shorted turns caused by mechanical damage or corrosion. | 3. Replace coil. |
| | 4. Under voltage, failure of magnet to seal in. | 4. Correct system voltage. |
| | 5. Dirt or rust on pole faces increasing air gap. | 5. Clean pole faces. |
| OVERLOAD RELAYS | | |
| Tripping | 1. Sustained overload. | 1. Check for grounds, shorts, or excessive motor currents and correct cause. |
| | 2. Loose connection on load wires. | 2. Clean and tighten. |
| | 3. Incorrect heater. | 3. Heater should be replaced with correct size. |
| MAGNETIC & MECHANICAL PARTS | | |
| Noisy Magnet | 1. Broken shading coil. | 1. Replace magnet and armature. |
| | 2. Magnet faces not mating. | 2. Replace magnet and armature. |
| | 3. Dirt or rust on magnet faces. | 3. Clean. |
| | 4. Low voltage. | 4. Check system voltage and voltage dips during starting. |
| Failure to Pick-up and Seal | 1. Low voltage. | 1. Check system voltage and voltage dips during starting. |
| | 2. Coil open or shorted. | 2. Replace. |
| | 3. Wrong coil. | 3. Replace. |
| | 4. Mechanical obstruction. | 4. WITH POWER OFF check for free movement of contact and armature assembly. |
| Failure to Drop-Out | 1. Gummy substance on pole faces. | 1. Clean pole faces. |
| | 2. Voltage not removed. | 2. Check coil circuit. |
| | 3. Worn or rusted parts causing binding. | 3. Replace parts. |
| | 4. Residual magnetism due to lack of air gap in magnet path. | 4. Replace magnet and armature. |
| PNEUMATIC TIMERS | | |
| Erratic Timing | 1. Foreign matter in valve. | 1. Replace timing head complete or return timer to factory for repair and adjustment. |
| Contacts Do Not Operate | 1. Maladjustment of actuating screw. | 1. Adjust as per instruction in service bulletin. |
| | 2. Worn or broken parts in snap switch. | 2. Replace snap switch. |
| LIMIT SWITCHES | | |
| Broken Parts | 1. Overtravel of actuator. | 1. Use resilient actuator or operate within tolerances of the device. |
| MANUAL STARTERS | | |
| Failure to Reset | 1. Latching mechanism worn or broken. | 1. Replace starter. |
| COMPENSATORS (MANUAL) | | |
| Welding of Contacts on Starting Side | 1. Inching, jogging, and operating handle slowly. | 1. Excessive inching and jogging not recommended (caution operator). Move handle swiftly and surely to start position. |

| | | |
|---|---|---|
| Welding of Contacts Running Side | 1. Moving handle slowly to run position. | 1. Move handle swiftly and surely to run position as motor approaches full speed. |
| | 2. Lack of sufficient spring pressure. | 2. Replace contacts and contact springs. |
| Damaged or Burned Transformer | 1. Repeated inching and jogging. | 1. Excessive inching and jogging not recommended (caution operator). |
| | 2. Holding handle in start position for long periods. | 2. Hold handle in start position only until motor approaches full speed. |

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# UNIT 14.0

# ELECTRIC MOTORS

This unit is designed to give the air conditioning, refrigeration, and heating student an introductory orientation to typical motors encountered in HVAC work. The student will learn the principles of electric motors, motor protection, and motor drives. Empahsis will be on practical installation, servicing, and troubleshooting of motors.

Learning activities may involve one or more tasks combined for instructional efficiency and organization of a project basis.

# MINIMUM SUGGESTED TERMINOLOGY

## ELECTRIC MOTORS

| | |
|---|---|
| INDUCATION MOTOR | AC motor in which stator is connected to power source, inducing current into a secondary winding called the rotor. |
| REPULSION MOTOR | Single-phase motor incorporating a commutator and brushes. |
| RESILIENT MOUNT | Rubber support on each end of motor which cushions the motor base from vibrations. |
| RIGID MOUNT | Mounting brackets permanently attached to the motor frame. |
| ROTOR | Rotating section which rotates within the stator of a motor. |
| RUN WINDING | Motor winding which has current flowing through it during normal operation. |
| SHADING COIL | Closed loop of wire placed in a slot in the motor's stator pole and provides a phase shift to aid in starting the motor and determining the direction of rotation. |
| SPLIT-PHASE MOTOR | Motor with two stator windings. Both windings are used for starting, then the starting winding is disconnected by centrifugal switch action after the motor is operating at about 80 percent of its run speed. Then the motor operates on the run winding only. |
| START WINDING | Electric motor winding used briefly to help start motor. |
| STATOR | Stationary section consisting of the windings and core which form the electromagnet that produces the magnetic field causing the motor to turn. |
| TORQUE | Twisting force created by a motor as it starts and runs. |

# HVAC
# ELECTRIC MOTORS
# SUGGESTED INSTRUCTION TIMES

| ELECTRIC MOTORS UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 14.0 | ELECTRIC MOTORS | |
| 14.01 | Connect Shaded-Pole Motor | * |
| 14.02 | Disassemble and Assemble a Single-Phase Motor | * |
| 14.03 | Measure Resistance or Windings in a Split-Phase Motor and Identify Start/Run Windings | * |
| 14.04 | Determine Common, Start, and Run Windings of a Single-Phase Compressor | * |
| 14.05 | Connect a Split-Phase Motor in a Given Circuit | * |
| 14.06 | (OPTIONAL) Reverse the Direction of Rotation of a Split-Phase Motor | * |
| 14.07 | Connect a Capacitor-Start Motor | * |
| 14.08 | Install a Permanent-Split Capacitor Motor (Compressor) | * |
| 14.09 | Determine Condition of Starting Components of a CSR Compressor | * |
| 14.10 | Disassemble/Assemble a Three-Phase Motor | * |
| 14.11 | Measure Resistance of Windings in a Single-Voltage, Single-Speed, Three-Phase Motor | * |
| 14.12 | Install a Single-Voltage Three-Phase Squirrel Cage Induction Motor | * |
| 14.13 | Connect a Dual-Voltage, Three-Phase Induction Motor for Low and High Voltage | * |

* - Total Time Estimated

|  |  |  |
|---|---|---|
| 14.14 | Start a Stuck Hermetic Motor Compressor | * |
| 14.15 | Adjust V-belt Tension | * |
| 14.16 | Replace Drive Pulley | * |
| 14.17 | Service an Electrical Motor | * |
| 14.18 | Install Gear Motor Station | * |
| 14.19 | Install Direct Drive Station | * |
| 14.20 | Identify Motor Bearing and Bushing Problems | * |
| 14.21 | Troubleshoot a Given Motor | * |
|  | Total Hours - | 15 |

* - Total Time Estimated

## TASK LISTINGS
## HVAC

| UNIT/TASK | Description |
|---|---|
| Unit 14.0 | ELECTRIC MOTORS |
| 14.01 | (CONNECT SHADED-POLE MOTOR) Provided with a functioning shaded-pole motor, AC power source, VOM (volt-ohms-amps meter), connection leads, electrical connectors, and the necessary tools and materials; connect a shaded-pole motor in a given cirucit. The motor must be correctly connected to the supply source; connections must be mechanically and electrically secure with no exposed wiring; and the motor must run at the rated speed. |
| 14.02 | (DISASSEMBLE AND ASSEMBLE A SINGLE-PHASE MOTOR) Provided with a functioning single-phase motor*, AC power source, VOM, and the necessary tools and materials; disassemble and assemble the motor.<br>*Non-functioning motor may be substituted for functioning motor and the task may emphasize troubleshooting.<br>Identify any problems that may be found in the motor. If the motor needs repair and the repair can be made practically in the field, repair and reassemble the motor. The reassembled motor should function properly when connected to the power source. |
| 14.03 | (MEASURE RESISTANCE OF WINDINGS IN A SPLIT-PHASE MOTOR AND IDENTIFY START/RUN WINDINGS) Provided with a functioning split-phase motor, a VOM, and the necessary tools and materials; measure the resistance of windings in a split-phase motor and correctly identify the start winding and run winding. Tag or mark the start and run windings if a terminal strip is not used to identify the windings. |
| 14.04 | (DETERMINE COMMON, START, AND RUN WINDINGS OF A SINLGE-PHASE COMPRESSOR) Provided with a single-phase compressor, a VOM (ohmmeter), and the necessary tools and materials; determine the common, start, and run (C, R, S) windings of the motor. Tag the windings or ensure that they are connected to the properly identified terminal. |
| 14.05 | (CONNECT A SPLIT-PHASE MOTOR IN A GIVEN CIRCUIT) Provided with a given circuit requiring a split-phase motor, a split-phase motor, an AC power source, a VOM and amprobe, connection leads and electrical |

connectors, and the necessary tools and materials; install the motor in the cirucit so that it is mechanically and electrically secure, correctly connected to the power source, and so it operates at the proper speed.

14.06 (REVERSE THE DIRECTION OF ROTATION OF A SPLIT-PHASE MOTOR) Using a given split-phase motor, AC power source, connecting leads and electrical connectors, and the necessary tools and materials; reverse the direction of rotation of a split-phase motor. The motor must be wired so that the motor will rotate in the desired direction and the electrical wiring must be mechanically and electrically secure and safe.

14.07 (CONNECT A CAPACITOR-START MOTOR) Provdied with a capacitor-start motor, AC power source, VOM, connection leads, electrical connectors, and the necessary tools and materials; connect the capacitor-start motor in a given cirucit. The motor must be wired correctly to the supply source with mechanically and electrically secure connections so that the motor runs at the rated speed.

14.08 (INSTALL A PERMANENT-SPLIT CAPACITOR MOTOR [COMPRESSOR]) Given a permanent-split capacitor (PSC) motor, AC power source, VOM, connection leads, electrical connectors, necessary tools and materials, and a cirucit in which to connect the motor; install the permanent-split capacitor motor. The PSC motor must be installed according to the wiring diagram/schematic. The motor must be wired with mechanically and electriclaly secure connections to the supply source. The motor must operate at the rated speed.

14.09 (DETERMINE CONDITION OF STARTING COMPONENTS OF A CSR COMPRESSOR) Provided with a capacitor run-capacitor start (CSR) compressor, VOM, and the necessary tools and materials; determine the condition of the starting components of a CSR compressor. All components will be identified as either open, shorted, grounded, or good.

14.10 (DISASSEMBLE/ASSEMBLE A THREE-PHASE MOTOR) Provided with a three-phase motor, three-phase power source, hand tachometer, VOM, and the necessary tools and materials; disassemble and assemble the motor. Upon assembly, when connected to the rated voltage source, the motor will operate according to the current and speed indicated on the manufacturer's identification plate or by given information.

14.11 (MEASURE RESISTANCE OF WINDINGS IN A SINGLE-VOLTAGE, SINGLE-SPEED, THREE-PHASE MOTOR) Provided with a three-phase motor, VOM, and the necessary tools and materials; check the resistance of the windings. The resistance must read the same on all windings if the motor is good.

14.12 (INSTALL A SINGLE-VOLTAGE , THREE-PHASE, SQUIRREL-CAGE INDUCTION MOTOR) Provided with a single-voltage, three-phase squirrel cage motor, a three-phase power source, a VOM, hand tachometer if available, connection leads, electrical connectors, and the necessary toola and materials; connect the single-voltage, three-phase motor to a given circuit according to diagrams provided. The motor must be connected correctly to the supply source; connections will be mechanically and electrically secure with no exposed wiring, and the motor must run at the rated speed.

14.13 (CONNECT A DUAL-VOLTAGE, THREE-PHASE INDUCTION MOTOR FOR LOW AND HIGH VOLTAGE) Provided with the functional dual-voltage, three-phase induction motor, three-phase power source, VOM, hand tachometer if available, connection leads, electrical connectors, and the necessary tools and materials; connect a dual-voltage, three-phase induction motor for low and high voltage. The motor must be wired for low and high voltage to the correct voltage source. Connections must be mechanically and electrically secure with no exposed wiring, and the motor must run at the rated speed.

14.14 (START A STUCK HERMETIC MOTOR COMPRESSOR) Given a stuck hermetic motor compressor (e.g., 120 volt motor), AC power source, leads and other test aids, required capacitors, and other materials and test equipemnt; free "break loose" the stuck compressor.

14.15 (ADJUST V-BELT TENSION) Given a belt driven device such as a blower, driven by electrical motor and pulley, information concerning the proper tension for the belt; adjust the V-belt tension. With pressure applied at the center of the belt, the belt should display the proper/recommended tension.

14.16 (REPLACE DRIVE PULLEY) Given a motor with a pulley, tool and equipment, replacement pulley, and other necessary materials; remove and replace the drive pulley. The replaced drive pulley must be in position, mechanically secure and aligned.

14.17 (SERVICE AN ELECTRICAL MOTOR) Given an electrical motor, instruction, and necessary cleaning materials and tools; provide proper service to the motor.

14.18 (INSTALL GEAR MOTOR STATION) Given a gear motor, a load, the necessary tools, equipment, and materials; install a gear motor station that will operate at hte rated voltage and speed.

14.19 (INSTALL DIRECT DRIVE STATION) Given a motor with a direct drive capability and a load, the necessary tools, equipment, and materials and a direct drive coupling; install a direct drive station. The driving machine must be coupled to the driven machine (load) so that there is no vibration transmitted to the load.

14.20 (IDENTIFY MOTOR BEARING AND BUSHING PROBLEMS) Given end bells, bearings, bushings, and tools, identify common motor bearing and bushing problems based on instruction. Bearings and bushings will be installed so the inside of the bearings are flush with the inside of the end bells. Performance must be to the instructor's standards.

14.21 (TROUBLESHOOT A GIVEN MOTOR) Given a possibly defective motor (single-phase or three-phase) and the necessary reference information for troubleshooting the motor, VOM, clamp-on ammeter such as Amprobe, required tools and materials; troubleshoot the motor and identify repair(s) needed or if the motor should be replaced. If the motor is repaired as an extension of this task, the motor when connected to its rated voltage, will operate under load at its rated speed and current (as given on the nameplate).

UNIT 14.0 ELECTRIC MOTORS

TASK 14.01 CONNECT SHADED-POLE MOTOR

---

PERFORMANCE OBJECTIVE:

Provided with a functioning shaded-pole motor, AC power source VOM (volt-ohms-amps meter), connection leads, electrical connectors, and the necessary tools and materials; connect a shaded-pole motor in a given circuit. The motor must be correctly connected to the supply source; connections must be mechanically and electrically secure with no exposed wiring; and the motor must run at the rated speed.

PERFORMANCE ACTIONS:

14.0101 Assemble motor.

14.0102 Disconnect power.

14.0103 Mount motor.

14.0104 Wire motor in electrical circuit.

14.0105 Check wiring.

14.0106 Connect power.

14.0107 Test motor for proper operation.

PERFORMANCE STANDARDS:

- Connect a shaded-pole motor in a given circuit so that the motor is properly wired with mechanically and electrically secure connections to the proper supply source and so the motor runs at the rated speed.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe operating characteristics of a shaded-pole induction motor.
- Identify advantages and disadvantages of a shaded-pole motor.
- Identify typical applications of shaded-pole motors in the HVAC field.
- Explain different ways for reversing shaded-pole motors.
- Determine if a given motor has open, shorted, or grounded leads.
- Explain formula for computing RPM's for a single-phase motor.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.02 DISASSEMBLE AND ASSEMBLE A SINGLE-PHASE MOTOR

---

PERFORMANCE OBJECTIVES:

Provided with a functioning single-phase motor*, AC power source, VOM, and the necessary tools and materials; disassemble and assemble the motor.

*Non-functioning motor may be substituted for functioning motor and the task may emphasize troubleshooting.

Identify any problems that may be found in the motor. If the motor needs repair and the repairs can be made practically in the field, repair and reassemble the motor. The reassemble motor should function properly when connected to the power source.

PERFORMANCE ACTIONS:

14.0201 Disconnect power.

14.0202 Remove motor.

(NOTE: Follow instructor's standards for motor disassembly.)

14.0203 Disassemble motor by:
a. Mark end bells.
b. Removing assembly bolts.
c. Removing end bells.
d. Removing from and stator windings from rotor and fans and shaft.
e. Remove windings from frame.

PERFORMANCE STANDARDS:

- Disassemble and assemble a single-phase motor, identifying any problems found and, if repairs can be accomplished practically, reassembling the motor and connecting it to the power source so that it operated at the proper speed or properly in a given circuit.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify components of a single-phase motor.
- Identify motor leads.
- Explain different methods used for starting single-phase motors.

TASK 14.02 DISASSEMBLE AND ASSEMBLE A SINGLE-PHASE MOTOR

---

RELATED TECHNICAL INFORMATION (Con't.):

- Explain starter windings.
- Explain multispeed windings.
- Explain dual-voltage windings.
- Identify wiring diagram.
- Describe how to use the tachometer or determine RPM's.
- Explain procedure for measuring voltage and amperage.
- Identify safety considerations.

EXPANSION OF TASK: (Clean Motor)

- With motor disassembled, clean motor with compressed air.
- Clean bearings.
- Check alignment of rotor and stator.
- Oil bearings as motor is assembled.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.03 MEASURE RESISTANCE OF WINDINGS IN A SPLIT-PHASE MOTOR AND IDENTIFY START/RUN WINDINGS

---

PERFORMANCE OBJECTIVE:

Provided with a functioning split-phase motor, a VOM, and the necessary tools and materials; measure the resistance of windings in a split-phase motor and correctly identify the start winding and run winding. Tag or mark the start and run windings if a terminal strip is not used to identify the windings.

(NOTE: This task may be accomplished in conjunction with one or more tasks concerning use of the VOM, measuring resistances, etc. /See related units and tasks./)

PERFORMANCE ACTIONS:

14.0301 Disconnect power.

14.0302 Set up ommeter.

14.0303 Prepare terminals or leads for measurements.

14.0304 Determine highest reading, second highest reading, and least reading. Start will be the second highest reading. Run will be the least reading, The highest reading will be between the S and R leads. Remaining leads will be common (C).

PERFORMANCE STANDARDS:

- Measure the resistance of start and run windings of a given split-phase motor and identify the windings as start and run.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how a split-phase motor is wound.
- Describe how to use a VOM (ohmmeter) to check motor windings.
- Explain the purpose and operating characteristics of start and run windings.
- Describe/Identify how to properly identify start the run windings (Identify terminal strip numbering and color code identification of windings).
- Identify safety considerations.

TASK 14.03 MEASURE RESISTANCE OR WINDINGS IN A SPLIT-PHASE MOTOR AND IDENTIFY START/RUN WINDINGS (Con't.)

---

ADDENDUM:

- Highest resistance is between Run and Start.
- Second highest resistance is between Start and Common.
- Least resistance is between Common and Run.
- The larger the motor, the less resistance.
- Be sure tha Start, Run, and Common terminals are clean (brushed) before measuring resistance so that a good electrical connection is made between the ohmmeter and motor winding.

## TASK 14.04 DETERMINE COMMON, START, AND RUN WINDINGS OF A SINGLE-PHASE COMPRESSOR

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PERFORMANCE OBJECTIVE:

Provided with a single-phase compressor, a VOM (ohmmeter), and the necessary tools and materials; determine the common, start, and run (C, R, S) windings of the motor. Tag the windings or ensure that they are connected to the properly identified terminal.

(NOTE: This task may be accomplished in conjunction with one or more other tasks. See related tasks and units.)

PERFORMANCE ACTIONS:

14.0401 Disconnect power.

14.0402 Set up ohmmeter.

14.0403 Prepare C, R, and S terminals or leads for measurements.

14.0404 Determine Common, Start, and Run windings of the motor or compressor:

TYPICAL RESISTANCE MEASUREMENTS

| HP | Run | Start |
|---|---|---|
| 1/8 | 4.7 ohms | 18 ohms |
| 1/6 | 2.7 ohms | 17 ohms |
| 1/5 | 2.3 ohms | 14 ohms |
| 1/4 | 1.7 ohms | 17 ohms |

(Source: Modern Refrigeration, Air Conditioning p. 240.)

14.0405 Highest reading is between start and run, second highest reading is between start and common, and least reading is between comon and run.

PERFORMANCE STANDARDS:

- Determine common (C), Start (S), and Run (R) windings of a given single-phase compressor.
- Mark windings or make sure they are connected to the correct identified terminals.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.04 DETERMINE COMMON, START, AND RUN WINDINGS OF A SINGLE-PHASE COMPRESSOR (Con't.)

---

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how a single-phase compressor is wound.
- Describe how to use the ohmmeter to check compressor windings.
- Explain the purpose of start and run windings.
- Identify safety considerations.

ADDENDUM:

- Shorted windings are indicated by two readings the same or almost the same. Minimum difference may be almost 1.5 ohms.
- Less than 1.5 ohms between any two terminals should be indicate an internal short.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.05 CONNECT A SPLIT-PHASE MOTOR IN A GIVEN CIRCUIT

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PERFORMANCE OBJECTIVE:

Provided with a given circuit requiring a split-phase motor, a split-phase motor, an AC power source, a VOM and amprobe, connection leads and electrical connectors, and the necessary tools and materials; install the motor in the circuit so that it is mechanically and electrically secure, correctly connected to the power source, and so it operates at the proper speed.

PERFORMANCE ACTIONS:

14.0501 Disconnect power source.

14.0502 Assemble parts and materials.

14.0503 Connect electrical wiring.

14.0504 Check circuit.

14.0505 Connect power source.

14.0506 Check operation of motor (proper rotation and amperage draw).

PERFORMANCE STANDARDS:

- Connect a split-phase motor in a given circuit so that it is mechanically and electrically secure, correctly connected to the power source, and so it operates as intended.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe how a split-phase motor operates.
- Identify the advantages and disadvantages of the split-phase motor.
- Identify motor leads and determine if they are open, shorted, or grounded.
- Describe how motor windings are identified by color coding or by terminal markings.
- Explain the operation of the centrifugal switch.
- Describe how to properly measure the starting and running current of a motor.
- Explain how to change the direction of rotation of a motor.
- Motor selected for a given circuit must be of correct electrical specifications.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.06 REVERSE THE DIRECTION OF ROTATION OF A SPLIT-PHASE MOTOR

---

PERFORMANCE OBJECTIVE:

Using a given split-phase motor, AC power source, connecting leads and electrical connectors, and the necessary tools and materials; reverse the direction of rotation of a split-phase motor. The motor must be wired so that the motor will rotate in the desired direction and the electrical wiring must be mechanically and electrically secure and safe.

PERFORMANCE ACTIONS:

14.0601 Gain access to the motor starting leads at the terminal, etc.

14.0602 Reverse the two starting winding leads so that the old "S" connection (lead) is on the "R" terminal and the "R" lead is on the "S" terminal.

(NOTE: Reversing the two main leads will not reverse the direction of rotation.)

14.0603 Properly connect the wiring so no hazard exists.

14.0604 Connect the AC source and test the motor rotation.

PERFORMANCE STANDARDS:

- Reverse the direction of rotation of a split-phase motor so the direction is in the opposite direction from the previous direction.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain standard rotation of a split-phase motor.
- Describe the procedure/method of changing the direction of rotation of a motor.
- Explain the purpose of the start winding and its function(s).
- Describe how the centrifugal mechanism works.
- Explain terminal numbers and color identification of start winding.
- Identify motor leads.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.07 CONNECT A CAPACITOR-START MOTOR

---

PERFORMANCE OBJECTIVE:

Provided with a capacitor-start motor, AC power source, VOM, connection leads, electrical connectors, and the necessary tools and materials; connect the capacitor-start motor in a given circuit. The motor must be wired correctly to the supply source with mechanically and electrically secure connections so that the motor runs at the rated speed.

PERFORMANCE ACTIONS:

14.0701 Switch power source off.

14.0702 Assemble parts and materials.

14.0703 Wire the motor correctly to the supply source.

14.0704 Check capacitor wiring if capacitor is located externally.

(NOTE: Low potential terminal (with red dot typically) is connected to the run terminal so that a shorted or grounded run capacitor will result in a direct short to ground: This will cause the line fuse or circuit breaker to trip and protect the motor. The capacitor could be connected differently (red to start) and the motor or compressor would operate; however, in case of a capacitor short, there would be no protection to ensure that the motor would not overheat and fail.)

14.0705 Switch power source on.

14.0706 Check operation of motor.

PERFORMANCE STANDARDS:

- Connect a capacitor-start motor in a given circuit so that electrical connections are mechanically and electrically secure and so the motor operates at the correct speed.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe the operating characteristics of a capacitor-start motor.
- Identify the advantages and disadvantages of a capacitor-start motor.
- Check motor leads for opens, shorts, and grounds.
- Describe the centrifugal mechanism.
- Describe the location and type capacitor for starting.
- Describe how to test a capacitor.
- Describe procedure for changing the direction of rotation.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.08 INSTALL A PERMANENT-SPLIT CAPACITOR MOTOR (COMPRESSOR)

---

## PERFORMANCE OBJECTIVE:

Given a permanent-split capacitor (PSC) motor, AC power source, VOM, connection leads, electrical connectors, necessary tools and materials; and a circuit in which to connect the motor; install the permanent-split capacitor motor. The PSC motor must be installed according to the wiring diagram/schematic. The motor must be wired with mechanically and electrically secure connections to the supply source. The motor must operate at the rated speed.

## PERFORMANCE ACTIONS:

14.0801 Assemble parts and materials.

14.0802 Switch power source off.

14.0803 Mount PSC motor (motor compressor).

14.0804 Wire motor properly so both start and run windings remain in motor circuit at all times and so running capacitor is in series with start winding and is used both for starting the motor and as a run capacitor to reduce current and increase the power factor.

14.0805 Switch power source on.

14.0806 Check operation and direction of motor. If motor does not start properly, check voltage.

(NOTE: A starting capacitor and starting relay may be added to the electrical circuit when low voltage or heavy loads exists and cause the loss or torque or prevent the motor from starting.)

## PERFORMANCE STANDARDS:

- Install a permanent-split capacitor motor in a given circuit according to the wiring diagram provided so that the motor operates at the rated speed and is mechanically and electrically connected securely to the supply source.

SUGGESTED INSTRUCTION TIME: Hours

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RELATED TECHNICAL INFORMATION:

- Describe the CSR motor operating characteristics.
- Identify the advantages and disadvantages of the CSR motor.
- Explain: Location, type, and purpose of both capacitors.
- Compute total capacitance with capacitors in parallel and capacitors in series.
- Identify motor leads and determine if open, shorted, or grounded.
- Explain: Centrifugal switch.
- Identify typical uses of CSR motors.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.09 DETERMINE CONDITION OF STARTING COMPONENTS OF A CSR COMPRESSOR

---

## PERFORMANCE OBJECTIVE:

Provided with a capacitor run-capacitor start (CSR) compressor, VOM, and the necessary tools and materials; determine the condition of the starting components of a CSR compressor. All components will be identified as either open, shorted, grounded, or good.

## PERFORMANCE ACTIONS:

14.0901 Disconnect power.

14.0902 Remove wiring as necessary.

14.0903 Determine windings of motor.

14.0904 Check for: Opens, Shorts, Grounds.

14.0905 Check resistance and continuity of starting winding.

14.0906 As necessary check capacitor, relay or wiring.

14.0907 Determine if CSR compressor is operational or needs replacement.

## PERFORMANCE STANDARDS:

- Determine the condition of the starting components of a CSR compressor as either open, shorted, grounded, or good.

SUGGESTED INSTRUCTION TIME: Hours

## RELATED TECHNICAL INFORMATION:

- Describe starting components.
- Explain characteristics of CSR compressor.
- Describe correct procedure for using the ohmmeter (VOM) for testing shorts, opens, and grounds.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.10 DISASSEMBLE/ASSEMBLE A THREE-PHASE MOTOR

---

## PERFORMANCE OBJECTIVE:

Provided with a three-phase motor, three-phase power source, hand tachometer, VOM, and the necessary tools and materials; disassemble and assemble the motor. Upon assembly, when connected to the rated voltage source, the motor will operate according to the current and speed indicated on the manufacturer's identification plate or by given information.

## PERFORMANCE ACTIONS:

14.1001 Disconnect electrical connections and remove motor from mounting as applicable.

14.1002 Remove assembly screws and nuts.

14.1003 Mark and remove end bell(s).

14.1004 Remove stator windings, rotor and fans, etc. from frame.

(NOTE: Disassembly should be according to techniques and procedures outlined by the instructor, manufacturer's data, or other guides. Care must be observed not to damage motor components, especially wiring.)

14.1005 Inspect, clean, and lubricate motor components as appropriate.

14.1006 Assemble motor by reversing above steps.

14.1007 Check resistance of assembled motor for shorts, opens, and grounds.

14.1008 If applicable, test motor for proper operation.

## PERFORMANCE STANDARDS:

- Disassemble/assemble a three-phase motor so that the assemble motor, when connected to the proper supply source, will operate at the proper speed using the rated current as given on the manufacturer's identification plate or given by the instructor.

TASK 14.10 DISASSEMBLE/ASSEMBLE A THREE-PHASE MOTOR (Con't.)

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SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Explain characteristic of a three-phase motor.
- Explain rotating magnetic field.
- Draw and explain a Delta connection.
- Draw and explain a Wye connection.
- Explain multi-speed.
- Explain dual-speed windings.
- Describe how to reverse motor direction.
- Identify motor leads.
- Identify relevant safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.11 MEASURE RESISTANCE OF WINDINGS IN A SINGLE-VOLTAGE, SINGLE-SPEED, THREE-PHASE MOTOR

---

PERFORMANCE OBJECTIVE:

Provided with a three-phase motor, VOM, and the necessary tools and materials; check the resistance of the windings. The resistance must read the same on all windings if the motor is good.

PERFORMANCE ACTIONS:

14.1101 Disconnect power from circuit.

14.1102 Expose leads or terminals to windings.

14.1103 Disconnect wiring as necessary.

14.1104 Using ohmmeter, measure resistance of windings.

(NOTE: The resistance must read the same on all windings if the motor is good.)

PERFORMANCE STANDARDS:

- Measure the resistance of the windings in a single-voltage, single-speed, three-phase motor.
- Resistance readings must be the same on all windings if the motor is good.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe the construction of a single-voltage, single-speed, three-phase motor.
- Describe procedures for using the ohmmeter to check the conditions of motor windings.
- Describe the difference in the number of leads in single-voltage, dual voltage, single-speed, multi-speed windings.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.12 INSTALL A SINGLE-VOLTAGE THREE-PHASE SQUIRREL-CAGE INDUCTION MOTOR

---

## PERFORMANCE OBJECTIVE:

Provided with a single-voltage, three-phase squirrel-cage motor, a three-phase power source, a VOM, hand tachometer if available, connection leads, electrical connectors, and the necessary tools and materials; connect the single-voltage, three-phase motor to a given circuit according to diagrams provided. The motor must be connected correctly to the supply source; connections will be mechanically and electrically secure with no exposed wiring, and the motor must run at the rated speed.

## PERFORMANCE ACTIONS:

14.1201 Disconnect electrical power.

14.1202 Remove existing motor, if applicable.

14.1203 Adjust/install/etc. motor mounting components.

14.1204 Mount motor.

- a. Connect leads according to wiring diagram/schematic.
- b. Check electrical connections.

14.1205 Turn on electrical power.

14.1206 Start motor.

- a. Observe motor operation.
- b. Test supply voltage and amperate and compare it with manufacturer's data plate/specifications.

14.1207 Stop motor.

## PERFORMANCE STANDARDS:

- Install a single-voltage, three-phase, squirrel-cage induction motor in a given circuit according to the diagram provided so that the motor is connected correctly to the supply source; has mechanically and electrically secure connections with no hazardous wiring, and operates at the rated speed.

SUGGESTED INSTRUCTION TIME: Hours

UNIT 14.0 ELECTRIC MOTORS

TASK 14.12 INSTALL A SINGLE-VOLTAGE THREE-PHASE SQUIRREL-CAGE INDUCTION MOTOR (Con't.)

---

RELATED TECHNICAL INFORMATION:

- Describe operating characteristics of single-voltage, three-phase, squirrel-cage induction motor.
- Identify advantages/disadvantages of the motor.
- Identify advantages/disadvantages of the three-phase motor verses the single-phase motor.
- Identify some typical uses of single-voltage, three-phase induction motors.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.13 CONNECT A DUAL-VOLTAGE, THREE-PHASE INDUCTION MOTOR FOR LOW AND HIGH VOLTAGE

---

PERFORMANCE OBJECTIVE:

Provided with a functional dual-voltage, three-phase induction motor, three-phase power source, VCM, hand tachometer if available, connection leads, electrical connectors, and the necessary hand tools and materials; connect a dual-voltage, three-phase induction motor for low voltage and high voltage. The motor must be wired for low and high voltage to the correct voltage source. Connections must be mechanically and electrically secure with no exposed wiring, and the motor must run at the rated speed.

PERFORMANCE ACTIONS:

14.1301 Identify voltage requirements of dual voltage motor.

14.1302 Connect windings in parallel low voltage.

14.1303 Test motor operation.

14.1304 Connect windings in series for high voltage operation.

14.1305 Test motor operation.

PERFORMANCE STANDARDS:

- Connect a dual-voltage, three-phase induction motor for low and high voltage.
- Connections must be wired for the proper voltages, connections must be mechanically and electrically secure with no hazards, and the motor must run at the rated speed.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Describe operating characteristics of a dual-voltage, three-phase induction motor.
- Identify advantages/disadvantages of the dual-voltage, three-phase induction motor.
- Identify typical applications of the dual-voltage, three-phase induction motor.
- Describe how to test motor windings.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.14 START A STUCK HERMETIC MOTOR COMPRESSOR

---

## PERFORMANCE OBJECTIVE:

Given a stuck hermetic motor compressor (e.g., 120 volt motor), AC power source(s), leads and other test aids, required capacitors, and other materials and test equipment; free("break loose") the stuck compressor.

## PERFORMANCE ACTIONS:

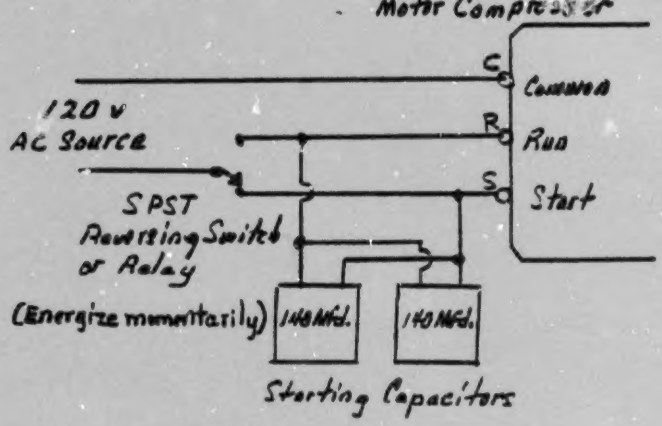
14.1401 Check for diagnostic signs of compressor failure, etc. If tests show nothing wrong but the compressor seems to be stuck, proceed.

14.1402 It may be necessary to change the motor compressor. However, the sticking may be the result of a temporary oil lock, piston and cylinder dry of oil, stuck unloader or some other similar cause.

14.1403 Follow the instructor's standard procedures for "breaking loose" a stuck compressor.

14.1404 Possible actions include:

a. Apply 240 volts for a brief time: Note, however, this may harm the motor winding if prolonged more than a second or two.
b. Use of a reversing-jogger set up:


Motor Compressor
C
Common
R
Run
S
Start
120 v
AC Source
SPST
Reversing Switch
or Relay
(Energize momentarily)
140 Mfd.
140 Mfd.
Starting Capacitors

c. Test amperage draw with ammeter.

TASK 14.14 START A STUCK HERMETIC MOTOR COMPRESSOR (Con't.)

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PERFORMANCE STANDARDS:

- Demonstrate an acceptable field technique or procedures for freeing a stuck motor compressor.
- The task may be actual or simulated.
- Emphasis will be on proper procedures or techniques acceptable to the instructor.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Procedure for reversing motors.
- Techniques for freeing stuck compressors (instructor provided).
- Familiarization with "Hard Start Kit".

TASK 14.15 ADJUST V-BELT TENSION

---

PERFORMANCE OBJECTIVE:

Given a belt driven device such as a blower, driven by electrical motor and pully, information concerning the proper tension for the belt; adjust the V-belt tension. With pressure applied at the center of the belt, the belt should display the proper/ recommended tension.

PERFORMANCE ACTIONS:

14.1501 Ensure that both shafts are parallel so belt will ride properly on the pulleys.

14.1502 Check belt for damage.

14.1503 Check (adjust) tension for approximately 1/2 inch give with about 10 pounds of force. (Approximately 1 inch movement at center is sometimes recommended.) Snug but not tight.

PERFORMANCE STANDARDS:

- Adjust V-belt tension so that with pressure applied at the center of the belt, the belt displays the recommended tension.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Identify different types of belts.
- Measuring belt length.
- Identify safety considerations.

EXPANSION OF TASK:

- Identify various types of pulleys found in HVAC installations.
- Adjustment of pulleys.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.16 REPLACE DRIVE PULLEY

---

PERFORMANCE OBJECTIVE:

Given a motor with a pulley, tools and equipment, replacement pulley, and other necessary materials; remove and replace the drive pulley. The replaced drive pulley must be in position, mechanically secure and aligned.

PERFORMANCE ACTIONS:

14.1601 Disconnect power.

14.1602 Remove belts or fans as applicable.

14.1603 Loosen pulley set screws.

14.0604 Attach wheel puller, if required.

14.0605 Clean and oil shaft.

14.1606 Remove flywheel.

14.1607 Clean and oil shaft.

14.1608 Install replacement pulley and alignment key if used.

14.1609 Position pulley correctly on shaft.

14.1610 Tighten set screw.

14.1611 Replace belts, etc.

14.1612 Connect power, start unit, check mechanical operation.

PERFORMANCE STANDARDS:

- Replace drive pulley so that new (replaced) pulley is in proper position, mechanically secure and aligned.

SUGGESTED INSTRUCTION TIME: Hours

RELATED TECHNICAL INFORMATION:

- Use of wheel puller, allen wrenches.
- Determining bore size of shaft.

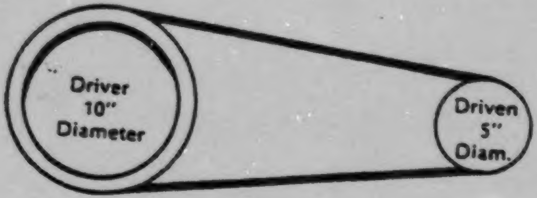
RELATED TECHNICAL INFORMATION (Con't.):

- Types of pulleys: Standard, V-step, closed and open adjustable V-pulley.
- Matching V-belts to pulley.
- Determining belt length.
- Prolonging belt life: Pulleys aligned, proper belt tension, belts clean and free from oil and grease, proepr belts used, etc.
- Use of straight edge for alignment.
- Determine RPM of driven device, given RPM of motor, motor pulley size, and driven device pulley size.

## SPEED OF MOTOR TO SPEED OF BELT DRIVEN FAN

Speed of motor x Diameter of Driver Pulley ÷ Diameter of Driven Pulley = Speed of Driven Pulley.

Sample: Motor 1725 RPM



1725 x 10 = 17250 ÷ 5 = 3450 RPM

UNIT 14.0 ELECTRIC MOTORS

TASK 14.17 SERVICE AN ELECTRICAL MOTOR

---

PERFORMANCE OBJECTIVE:

Given an electrical motor, instruction, and necessary cleaning materials and tools; provide proper service to the motor.

PERFORMANCE ACTIONS:

14.1701 Disconnect power from motor.

14.1702 Clean the motor of dust and dirt accumulation that might cause overheating by preventing air flow, etc. Clean dust and dirt from fans, etc., that might cause an unbalance on the motor.

14.1703 Check bearings for excessive end play or wear (horizontal and veritcal).

14.1704 Check shaft for freedom of rotation.

14.1705 Lubricate the motor according to manufacturer's recommendations, being careful not to over lubricate.

14.1706 Check for loose, frayed, or bear wiring.

14.1707 Clean starting switch contacts where applicable. Use correct procedures: Emery cloth tends to insulate points where fine sandpaper does not.

14.1708 Check brushes on wound rotor motors.

14.1709 Clean brushes and commutator where applicable. Fine sandpaper is recommended.

14.1710 Check drive mechanisms: Belt for tension and condition and pulleys for alignment.

PERFORMANCE STANDARDS:

- Service an electrical motor according to manufacturer's recommendations and standard shop procedures.

SUGGESTED INSTRUCTION TIME: Hours

---

RELATED TECHNICAL INFORMATION:

- Lubricating cooling tower gear reducer fan drives with special oils such as turbine oils with antioxidant inhibitors and the need for changing the oil in cooling towers yearly due to the wet atmosphere.
- Importance of selecting the proper type of oil for the lubrication job and the dangers of mixing oils that are not compatible.
- Grease lubrication: Know that auto chassie lubricating grease may ruin ball bearings. Ball bearing grease is not appropriate in a water pump that requires lithium based grease. Remember, most bearings are ruined from over lubrication rather than under lubrication.

## RECOMMENDED MAINTENANCE SCHEDULE FOR MOTORS
(AC and DC Motors)
/Based on an average environment/

### "EVERY WEEK

1. Examine commutator and brushes.
2. Check oil level in bearings.
3. See that oil rings turn with shaft.
4. See the exposed shaft is free of oil and grease from bearings.
5. Examine the starter switch, fuses, and other controls.
6. See that the motor is brought up to speed in normal time.

### EVERY SIX MONTHS

1. Clean motor thoroughly, blowing out dirt from windings, and wipe commutator and brushes.
2. Inspect commutator clamping ring.
3. Check brushes and replace any that are more than half worn.
4. Examine brush holders, and clean them if dirty. Make certain that brushes ride free in the holders.
5. Check brush pressure.
6. Check brush position.
7. Drain, wash out, and replace oil in sleeve bearings.
8. Check grease in ball or roller bearings.
9. Check operating speed or speeds.
10. See that end play of shaft is normal.
11. Inspect and tighten connections on motor and control.
12. Check current input and compare it with normal.
13. Examine drive, critically, for smooth running, absence of vibration, and worn gears, chains, or belts.
14. Check motor foot bolts, end-shield bolts, pulley, coupling, gear and journal set-screws, and keys.
15. See that all covers, and belt and gear guards are in place, in good order, and securely fastened.

### ONCE A YEAR

1. Clean out and renew grease in ball or roller bearing housings.
2. Test insulation by megohmmeter.
3. Check air gap.
4. Clean out magnetic dirt that may be clinging to poles.
5. Check clearance between shaft and journal boxes of sleeve bearing motors to prevent operation with worn bearings.
6. Clean out undercut slots in commutator. Check the commutator for smoothness.
7. Examine connections of commutator and armature coils.
8. Inspect armature bands".

Alerich, Walter N., Electricity 4: AC Motors, Controls, and Alternators, Albany, NY: Delmar Publishers Inc., pp. 161-162, 1981. (See Chapter 14, Motor Maintenance for additional information.)

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UNIT 14.0 ELECTRICAL MOTORS

TASK 14.18 (Optional) INSTALL GEAR MOTOR STATION

---

PERFORMANCE OBJECTIVE:

Given a gear motor, a load, the necessary tools, equipment, and materials; install a gear motor station that will operate at the rated voltage and speed.

PERFORMANCE ACTIONS: (Actions will be determined by instructor and training materials.)

PERFORMANCE STANDARDS:

- Install a gear motor station that will operate as intended.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain basic operation of gear motor drives.
- Explain where gear motors might be used.
- Explain gear selection for different operations.
- Identify safety considerations.

EXPANSION OF TASK: (OPTIONAL)

- Given a chain-and-sprocket drive, install the drive so it operates as intended. (Determine sprocket socket size, teeth per inch, and chain size.)

UNIT 14.0 ELECTRICAL MOTORS

TASK 14.19 (Optional) INSTALL DIRECT DRIVE STATION

---

PERFORMANCE OBJECTIVE:

Given a motor with a direct drive capability and a load, the necessary tools, equipment, and materials and a direct drive coupling; install a direct drive station. The driving machine must be coupled to the driven machine (load) so that there is no vibration transmitted to the load.

PERFORMANCE ACTIONS: (Actions will be determined by instructor and training materials.)

PERFORMANCE STANDARDS:

- Install a direct drive station so that there is no vibration transmitted from the driving machine to the driven machine (load).

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain advantages of direct and pulley drives.
- Identify several types of direct drives (Flexible-hose, flange, flexible shaft).
- Explain alignment procedures for direct coupling both angular and axis.
- Identify safety considerations.

UNIT 14.0 ELECTRIC MOTORS

TASK 14.20 IDENTIFY MOTOR BEARING AND BUSHING PROBLEMS

---

PERFORMANCE OBJECTIVE:

Given end bells, bearings, and bushings, and tools, identify common motor bearing and bushing problems based on instruction. Bearings and bushings will be installed so the inside of the bearings are flush with the inside of the end bells. Performance must be to the instructor's standards.

PERFORMANCE ACTIONS:

14.2001 Identify precautions in cleaning bearings and in handling new bearings.

14.2002 Describe how typical motor bearings are removed.

14.2003 Describe or identify common types of bearing damage and failure in motors.

14.2004 Identify bearing lubrication considerations, steps, and precautions.

PERFORMANCE STANDARDS:

- Identify motor bearing and bushing problems in instructor provided motors or parts to the standards of the instructor.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain purpose of bearings and bushings.
- Describe the operation of a bearing tool.
- List typical causes of bearing and bushing failure:
  a. Installation damage:
    (1) Brinelling
    (2) Scoring
  b. Operating condition damage:
    (1) Loose housing fir or loose shaft
    (2) Splitting
    (3) Cracking
    (4) Misalignment
    (5) Vibration brinell
    (6) Inadequate lubrication
    (7) Abrasive wear
  c. Normal fatique:
    (1) Pitting
- Appendix section concerning bearing problems is available for this task objective page.

TASK 14.21 TROUBLESHOOT A GIVEN MOTOR

---

PERFORMANCE OBJECTIVE:

Given a possibly defective motor (single-phase or three-phase) and the necessary reference information for troubleshooting the motor, VOM, clamp-on ammeter such as Amprobe, required tools and materials: troubleshoot the motor and identify repair(s) needed or if the motor should be replaced. If the motor is repaired as an extension of this task, the motor when connected to its rated voltage, will operate under load at its rated speed and current (as given on the nameplate).

PERFORMANCE ACTIONS: (See pictorial suggestions. Courtesy of Amprobe Co.)

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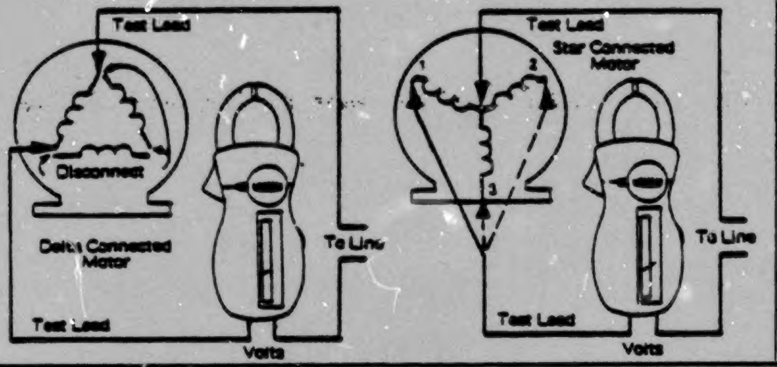
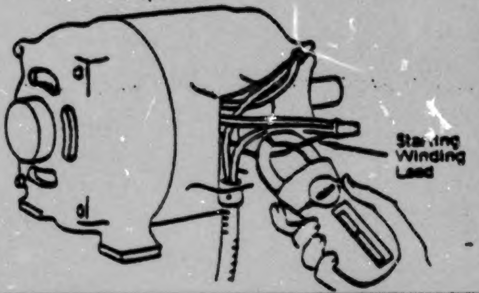
**Figure 1 - Locating Open**
Winding is open if there is no voltage indication across the winding.



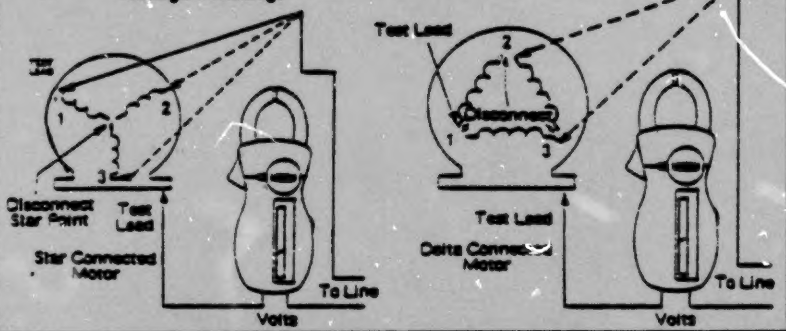
Test Lead
Disconnect
Delta Connected Motor
Test Lead
Volts
To Line
Test Lead
Star Connected Motor
1
2
3
Test Lead
Volts
To Line

**Figure 3 - Testing Centrifugal Switch**
Current indication after motor is up to speed means centrifugal switch did not open.



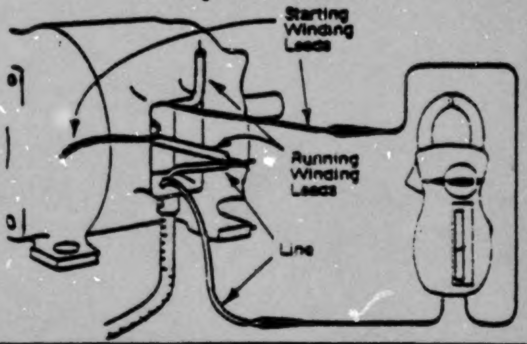
Starting Winding Lead

**Figure 2 - Finding Location of Grounded Phase**
Grounded phase is indicated by a full line voltage reading.



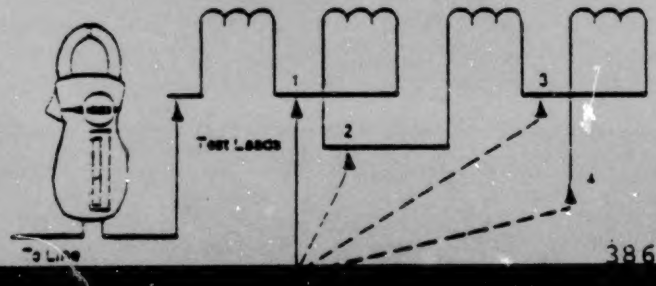
1
2
3
Disconnect Star Point
Test Lead
Star Connected Motor
To Line
Volts
Test Lead
1
2
3
Disconnect
Test Lead
Delta Connected Motor
To Line
Volts

**Figure 4 - Test for Winding Short Circuit**
With running and starting windings and instrument connected as shown, full line voltage reading means two windings are shorted.



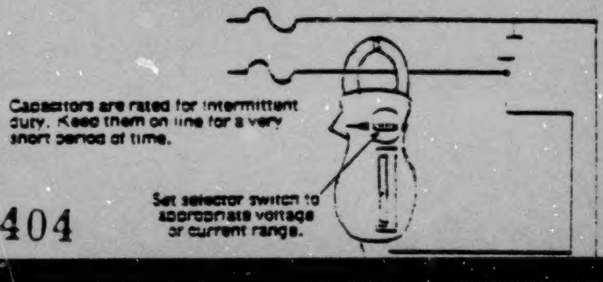
Starting Winding Leads
Running Winding Leads
Line

**Figure 5 - Isolating Open Phase**
Winding is open if there is no voltage indication across the winding.



1
2
3
4
Test Leads
To Line

**Figure 6 - Checking AC Electrolytic Capacitors**
If there is no current indication, capacitor is open. Shorted capacitor will blow fuse when line voltage is applied.



Capacitors are rated for intermittent duty. Keep them on line for a very short period of time.

Set selector switch to appropriate voltage or current range.

UNIT 14.0 ELECTRICAL MOTORS

TASK 14.21 TROUBLESHOOT A GIVEN MOTOR

---

PERFORMANCE STANDARDS:

- See objective. Standards of the instructor apply.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- A. TROUBLESHOOT A SINGLE-PHASE MOTOR
  - Explain procedure used to determine grounds in the run and start windings.
  - Explain procedure used to determine openings in the run and start windings.
  - Explain procedure for detecting shorts in the run and start windings.
  - Explain reverses.
  - Explain probable causes for a motor failing to start.
  - Explain probable causes for a motor running slower than normal speed.
  - Explain probable causes for a motor running hot.
  - Explain probable causes for motor noise.

- B. TROUBLESHOOT A THREE-PHASE MOTOR
  - Explain procedure used for determining grounds in each phase winding.
  - Explain procedure used for determining openings in each phase winding.
  - Explain procedures used for determining shorts in each winding.
  - Explain reverse coil.
  - Explain reverse coil groups.
  - Explain reverse phases.
  - Identify the probable causes for a motor failing to start.
  - Identify the probable causes for a motor not running properly.

- C. TROUBLESHOOTING A DC MOTOR (OPTIONAL)
  - Explain procedures for finding grounds in the fields, armature, and brush holders.

RELATED TECHNICAL INFORMATION (Con't.):

- Describe procedure for determining a cumlative or differential connection.
- Describe test procedures for determining interpole polarity.
- Describe positioning of brush holders.
- Identify safety considerations.

MOTOR TROUBLESHOOTING GUIDE APPENDIX ACCOMPANIES THIS TASK

## TRCUBLE-SHOOTING GUIDE FOR ALL MOTORS

SYMPTOMS

| to start | Motors hums bu will not start | Rotor must be shifted to start | Motor runs--then stops | Slow acceleration | Overheating | Excessive vibration | Low speed | PROBABLE CAUSE | RECOMMENDED ACTIONS |
|---|---|---|---|---|---|---|---|---|---|
| x |  | x |  |  |  |  |  | Open circuit | Check wiring--Check voltage |
| x |  |  |  |  |  |  |  | Defective motor windings | Inspect and repair |
|  | x |  |  |  |  |  |  | Starter switch doesn't close | Clean and lubricate, or replace |
|  | x |  |  | x | x |  |  | Bad capacitor | Check and replace |
|  |  | x |  |  |  |  |  | Open rotor or starter | Locate and replace |
|  | x |  | x | x | x |  | x | Overloaded | Lighter load |
|  | x |  |  | x |  |  | x | Low voltage | Lighter line load--Increase size of lead wire |
|  | x |  |  |  | x | x |  | Worn bearings | Replace |
|  | x |  |  |  | x |  |  | Lack of Lubrication | Lubricate |
|  |  |  | x |  |  |  |  | Defective over-load protection | Locate and replace |
|  |  |  |  |  |  | x |  | Grounds or short circuits | Locate and repair |
|  |  |  |  |  | x |  | x | Wrong connections | Check wiring diagrams |
|  |  |  |  |  | x |  |  | Belt too tight | Slacken belt |
|  |  |  |  |  | x |  |  | Dirt, dust, trash | Clean |
|  |  |  |  |  |  | x |  | Unbalanced | Balance |
|  |  |  |  |  |  | x |  | Misalignment | Align |
|  |  |  |  |  |  | x |  | Loosen mounting | Tighten |
| x | x |  |  |  |  |  |  | Poor connection | Inspect and connect |

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## TROUBLE-SHOOTING GUIDE FOR MOTORS WITH BRUSHES

| SYMPTOMS |  |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Motor fails to start | Slow acceleration | Low speed | Excessive sparking--starting | Excessive sparking--running | Rapid brush wear | Excessive speed | PROBABLE CAUSE | RECOMMENDED ACTION |
| x |  | x | x | x |  |  | Worn brushes | Replace brushes |
| x | x | x | x |  |  |  | Brushes stuck | Adjust brushes |
| x | x | x |  |  |  |  | Brushes not set | Check with marks on frame |
|  | x | x | x |  |  |  | Dirty commutator | Clean and sandpaper |
|  | x | x |  |  | x |  | Rough commutator | Clean and sandpaper |
|  |  |  | x |  | x |  | High commutator bars | Turn in lathe |
|  |  |  | x |  | x |  | High mica | Undercut mica |
|  |  |  | x |  | x |  | Overloaded | Lighten load |
|  |  |  | x |  |  |  | High voltage | Check voltage |
|  |  |  | x |  | x |  | Low voltage | Check voltage |
|  |  |  |  |  |  | x | Governor stuck | Adjust governor |
|  |  |  |  |  |  | x | Governor out of adjustment | Adjust governor |
|  |  |  |  |  | x |  | Poor connections | Test and tighten |
|  |  |  |  |  | x |  | Commutator out of round | Turn in lathe |
|  |  |  |  | x |  | x | Dirty short circuiting device | Clean with solvent |
| x |  |  |  |  |  |  | Shorted rotor winding | Inspect and repair |

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# UNIT 15.0

# DOMESTIC REFRIGERATION SERVICING

The purpose of this unit is to build on basic refrigeration theory and fundamentals and introduce the secondary student to domestic refrigeration servicing principles.

Although task descriptions are intended to be general actions applicable to a variety of makes of domestic refrigerators, some descriptions may be more suitable for one make of domestic refrigerator unless there is modification at the instructional level.

In addition, some tasks will be related to servicing domestic freezers. As needed, the instructor may expand this unit to include servicing domestic freezers.

Primarily, this unit describes the overall training proposed for the secondary level. Training objectives and actions may vary according to the makes of refrigerators being used for instruction.

Instruction need not follow the order of tasks in this unit: Instruction may be organized around a logical sequence determined by the instructor.

This unit does not include all task objectives that might be a part of training the student to service domestic refrigerators. Refrigerator servicing tasks that may have been omitted from this unit should be added by the instructor.

## HVAC
## DOMESTIC REFRIGERATOR SERVICING
## SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 15.0 | DOMESTIC REFRIGERATOR SERVICING | |
| 15.01 | Adjust Refrigerator Door | * |
| 15.02 | Remove and Replace a Gasket | * |
| 15.03 | Remove and Replace Breaker Trim/ Strip (OPTIONAL) | * |
| 15.04 | Remove and replace Temperature Control | * |
| 15.05 | Test Refrigerator Thermostat | * |
| 15.06 | Test Defrost Termination Thermostat | * |
| 15.07 | Defrost Termination Thermostat | * |
| 15.08 | Test Defrost Timer | * |
| 15.09 | Test Defrost Heater | * |
| 15.10 | Replace Defrost Heater | * |
| 15.11 | Diagnose and Repair Domestic Refrigerator Electrical Circuits | * |
| 15.12 | Locate and Repair an Evaparator Leak | * |
| 15.13 | Clean Capillary Tubing | * |
| 15.14 | Install Inline Service Stub | * |
| 15.15 | Check Hermetic Compressor for Pumping Efficiency | * |
| 15.16 | Remove and Replace a Hermetic Compressor | * |
| 15.17 | Install Refrigerator Equipped with Ice Maker | * |
| 15.18 | Adjust Water Level Switch on Ice Maker | * |

| | | |
|---|---|---|
| 15.19 | Replace Defective Ice Maker | * |
| 15.20 | Remove and Replace Mold Heater | * |
| 15.21 | Troubleshoot Domestic Refrigerator or Freezer | * |
| | Total Hours - | 15 |

* - Total Time Estimated

# TASK LISTINGS
# HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 15.0 | DOMESTIC REFRIGERATOR SERVICING |
| 15.01 | (ADJUST REFRIGERATOR DOOR) Given a domestic refrigerator and the necessary tools, feeler guage or test light, adjust the refrigerator door so that it will open and close evenly and seal properly. |
| 15.02 | (REMOVE AND REPLACE A GASKET) Given a refrigerator and the necessary tools, test equipment, and replacement gasket, remove and replace the gasket, securely attaching the new gasket so the door will seal properly. |
| 15.03 | (REMOVE AND REPLACE BREAKER TRIM/STRIP) Given a refrigerator and breaker trim removal tool, remove and replace the breaker trim (strip). The trim will not be broken or cracked and will fit back tightly. |
| 15.04 | (REMOVE AND REPLACE TEMPERATURE CONTROL) On a given refrigerator, using mechanics hand tools and equipment, temperature recorder, and other necessary materials; remove and replace the temperature control. The installed control must be wired according to the manufacturer's schematic/diagram (or mechanic's sketch) and the unit must cycle. |
| 15.05 | (TEST REFRIGERATOR THERMOSTAT) Given a refrigerator and the necessary test equipment, test the refrigerator thermostat. Determine if the thermostat is cycling according to the manufacturer's specifications. |
| 15.06 | (TEST DEFROST TERMINATION THERMOSTAT) Given a refrigerator and the necessary test equipment, determine the condition of the defrost termination thermostat. The defrost termination thermostat will open at 70 degrees and close and +10 degrees. |
| 15.07 | (REMOVE AND REPLACE THE DEFROST TERMINATION THERMOSTAT) Given a refrigerator with a faulty defrost termination thermostat and access to the proper tools, test equipment, and a replacement defrost termination thermostat; remove and replace the defrost termination thermostat. The defrost termination thermostat must be wired according to the manufacturer's diagram and must cycle the defrost heater on and off. |

15.08 (TEST DEFROST TIMER) Given a refrigerator and the necessary test equipment, test the defrost timer. Determine if timer cycling is according to the manufacturer's specifications.

15.09 (TEST DEFROST HEATER) Given a refrigerator and the necessary test equipment, test the defrost heater. The heater will be open, shorted, grounded, or good.

15.10 (REPLACE A DEFROST HEATER) Given a refrigerator with a defective defrost heater, test equipment such as the ammeter, mechanics tools and equipment, defrost heater replacement, and other materials needed; remove and replace the defrost heater. The new heater must be wired according to the unit schematic diagram and the freezer must defrost properly .

15.11 (DIAGNOSE AND REPAIR DOMESTIC REFRIGERATOR ELECTRICAL CIRCUIT) Given a domestic refrigerator and test equipment, tools and materials; diagnose and repair electrical circuits. Identify and correct shorts, opens, and grounds so the unit operates correctly.

15.12 (LOCATE AND REPAIR AN EVAPARATOR LEAK) Given an evaparator with a leak, epoxy glue, and the necessary tools and materials; locate and repair the evaparator leak. The evaparator will not leak under pressure of 60 psi.

15.13 (CLEAN CAPPILARY TUBING) Given a refrigerator with restricted capillary tube, capillary tube cleaner, flat file, torch, sond cloth, silver brazing alloy, silver solder flux, 1/4 inch copper o.d., 1/4 inch flare nut, mechanics tools, tubing cutter, and other required materials; clean the capillary tubing. The capillary tubing must equalize and the unit must cycle.

15.14 (INSTALL INLINE SERVICE STUB) Given a refrigerator, torch, sand cloth, silver brazing alloy, silver solder slux, shop towels, side cutters, tubing cutters, copper tubing, striker, sweat tee, and the necessary tools and materials; install an in-line service stub using proper procedures and safety precautions. The service stub will not leak and will be long enough for pinch of after use.

15.15 (CHECK HERMETIC COMPRESSOR FOR PUMPING EFFICIENCY) Given a compressor and the necessary tools, test instruments, and equipment such as mechanics tools, guage set, line piercing valve, torch kit, pinch-off tool, ammeter, safety glasses, etc.; test the compressor for pumping efficiency. The compressor should pump no less than 25 inches of mercury vacuum while pumping 125 psi head pressure.

15.16 (REMOVE AND REPLACE A HERMETIC COMPRESSOR) Given a refrigerator with a faulty compressor, and the necessary tools and equipment, brazing unit, replacement compressor; remove and replace the compressor. Brazed joints will be leakproof, wiring will be according to the schematic or diagram provided, and the compressor will be mounted securely and charged to specifications. The unit should operate as intended.

15.17 (INSTALL REFRIGERATOR EQUIPPED WITH ICE MAKER) Given a domestic refrigerator equipped with an ice maker, mechanics tools, tubing cutter, 5/32" and 3/8" drill bits, 3/8" portable drill, water line saddle valve, roll of 1/4 inch o.d. copper tubing, and other materials needed; install the domestic refrigerator equipped with an ice maker.

15.18 (ADJUST WATER LEVEL SWITCH ON ICE-MAKER) Given a refrigerator ice-maker and the necessary tools and materials, adjust the water level. The water level will be no less than 1/4 inch from the top of the mold and will not overflow.

15.19 (REPLACE DEFECTIVE ICE-MAKER) Given a refrigerator with a defective ice-maker and the necessary tools and materials; remove a defective ice-maker and install a replacement unit. Electrical connections must be mechanically and electrically secure and leads and connections must be wired according to the manufacturer's schematic, soldered connections must form a tight seal and joints must be leakproof, and the water meter valve will flow according to manufacturer's specifications.

15.20 (REMOVE AND REPLACE MOLD HEATER) Given a refrigerator with an ice-maker and the necessary tools and materials, remove and replace a mold heater. The mold heater will heat the mold during the harvest cycle and be firmly in place.

15.21 (TROUBLESHOOT A DOMESTIC REFRIGERATOR OR FREEZER) Given a refrigerator with a possible malfunction, mechanics tools and equipment, VOM and amprobe, guage set and refrigerant as needed, and other required parts and supplies; troubleshoot and repair a domestic refrigerator or freezer (if assigned) so that problem is properly identified and the unit is repaired if possible. Performance must be to the instructor's standards.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.01 ADJUST REFRIGERATOR DOOR

---

PERFORMANCE OBJECTIVE:

Given a domestic refrigerator and the necessary tools, feeler gauge or test light, adjust the refrigerator door so that it will open and close evenly and seal properly.

PERFORMANCE ACTIONS: (Refer to manufacturer's service manual for actions: Different makes may have different actions:

15.0101 Using spirit level, level refrigerator cabinet.

15.0102 Check door alignment and sealing ability of gasket (using a .003 inch feeler gauge* or test light).

15.0103 If door hardware is out of alignment, repair by changing the adjustment of the hinge assembly.

15.0104 Check gasket tightness again and readjust hinges as necessary.

15.0105 Check with test kight to determine proper fit.

15.0106 Clean up after work.

* - A dollar bill may be used in place of .003 inch feeler gauge if necessary.

PERFORMANCE STANDARDS:

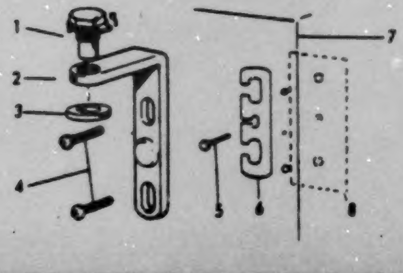
- Adjust domestic refrigerator door so that it will open and close evenly and seal properly.
- Meet manufacturer's or instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe what happens when air escapes or enters a refrigerator.
- Explain procedure for adjusting a refrigerator door.
- Identify function of hinges and locks.
- Identify safety considerations.

Typical upper door hinge.



1. Pin for Top Hinge Bracket
2. Top Hinge Bracket
3. Nylon Bearing for Pin
4. Screw for Top Hinge Bracket to Cabinet
5. Tapping Plate Retainer Pin
6. Shim for Top Hinge Bracket
7. Cabinet Outer Shell
8. Tapping Plate for Top Hinge Bracket

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UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.02 REMOVE AND REPLACE A GASKET

---

## PERFORMANCE OBJECTIVE:

Given a refrigerator and the necessary tools, test equipment, and replacement gasket. remove and replace the gasket, securely attaching the new gasket so the door will seal properly.

## PERFORMANCE ACTIONS:

15.0201 Check level of cabinet.

15.0202 Check door alignment and sealing ability of gasket (with feeler gauge or with test lamp).

15.0203 If door hardware is not in alignment, adjust hinge assembly.

15.0204 Check door alignment and sealing ability of gasket.

15.0205 If there is leakage (improper seal), replace gasket.
  a. Remove old gasket.
  b. Clean surfaces.
  c. Allow plastic strips to reach ambient temperature before installing them with putty knives.
  d. Replace gasket with same style gasket.
  e. Check fit of corners (using gasket notcher).

15.0206 Check installation with test light to determine that fit is acceptable.

## PERFORMANCE STANDARDS:

- Remove and replace a domestic refrigerator gasket so that the door will seal properly.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Explain procedure for checking a door gasket.
- Describe how to remove a gasket.
- Describe how to replace a gasket.
- Identify safety considerations.

---

## WORK NOTES

Refrigerator: Type/Name ________________________ Make ____________
Gasket: Type ________________________ Material ____________________
Method of Holding Gasket: () Adjesive () Inner Panel () Staples

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.03 REMOVE AND REPLACE BREAKER TRIM/STRIP

---

PERFORMANCE OBJECTIVE:

Given a refrigerator and breaker trim removal tool, remove and replace the breaker trim/strip. The trim/strip will not be broken or cracked and will fit back tightly.

PERFORMANCE ACTIONS:

15.0301 Open door.

15.0302 Warm breaker trim/strips. (75-100 degrees F is generally recommended.

15.0303 Place masking tape around putty knives.

15.0304 If there are cornerpieces, remove them by gently prying with putty knives.

15.0305 Insert knives gently between inner liner and breaker trim/strips.

15.0306 Gradually warp breaker strip from its position without scratching the plastic or metal shell edges.

15.0307 Replace breaker strip gently.

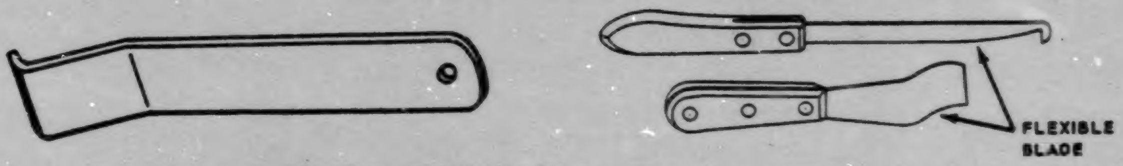
PERFORMANCE STANDARDS:

- Remove and replace breaker trim/strip so the trim is not broken or cracked and fits back tightly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how to use breaker trim tool.
- Identify purpose of location of breaker trims ("cold ban").
- Identify safety considerations.



Tools for removing plastic strips

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.04 REMOVE AND REPLACE TEMPERATURE CONTROL

---

## PERFORMANCE OBJECTIVE:

On a given refrigerator, using mechanic's hand tools and equipment, temperature recorder, and other necessary materials; remove and replace the temperature control. The installed control must be wired according to the manufacturer's schematic/diagram (or mechanic's sketch) and the unit must cycle.

## PERFORMANCE ACTIONS:

15.0401 Disconnect electrical power form refrigerator.

15.0402 Remove knob from temperature control.

15.0403 Remove temperature control mounting screws.

15.0404 Pull control out enough to disconnect wires.

15.0405 Disconnect sensing element form evaporator if it is secured to it.

15.0406 Carefully remove sensing element. (Do not kink or break sensing element.)

15.0407 Straighten sensing element of new temperature control.

15.0408 Inserting sensing element.

15.0409 Attach wires to control.

15.0410 Place control in proper position.

15.0411 Replace mounting screws.

15.0412 Attach sensing element to evaporator in same manner as original.

15.0413 Check to be sure that the sensing element touches only where intended.

15.0414 Replace control knob.

15.0415 Check installation.

15.0416 Plug in refrigerator to wall outlet.

15.0417 Set temperature control at mid-range.

---

PERFORMANCE ACTIONS (Con't.):

15.0418 Place temperature recorder in refrigerator.

15.0419 Run refrigerator for about 24 hours.

15.0420 Check chart for cycling pattern.

PERFORMANCE STANDARDS:

- Remove and replace temperature control of a refrigerator so that the unit is wired according to original circuit and cycles properly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain operation of temperature control.
- Describe how to select a temperature control.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.05 TEST REFRIGERATOR THERMOSTAT

---

PERFORMANCE OBJECTIVE:

Given a refrigerator and the necessary test equipment, test the refrigerator thermostat. Determine if the thermostat is cycling according to the manufacturer's specifications.

PERFORMANCE ACTIONS:

15.0501 Scrap away frost on inside of evaporator adjacent to feeler-tube thermal connection.

15.0502 Using a few drops of water, freeze the bulb of an accurately calibrated remote reading thermometer to the evaporator.

15.0503 Set control at normal. Close unit door and allow compressor to run through 2-3 complete cycles.

15.0504 Check refrigerator thermostat against calibrated thermostat and "specification chart".

PERFORMANCE STANDARDS:

- Determine if a refrigerator thermostat is cycling according to manufacturer's specifications.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how to mearue resistance with the VOM.
- Describe hot to test cut-in and cut-out temperatures.
- Explain a constant cut-in.
- Explain why a constant cut-in temperature is set to approximately 37 degrees (above frost point).

UNIT 15.0 DOMESTIC REFRIGERATION

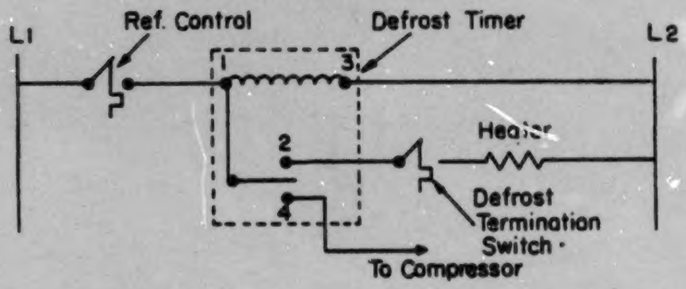
TASK 15.06 TEST DEFROST TERMINATION THERMOSTAT

---

PERFORMANCE OBJECTIVE:

Given a refrigerator and the necessary test equipment, determine the condition of the defrost termination thermostat. The defrost termination thermostat will open at 70 degrees and close at +10 degrees.

PERFORMANCE ACTIONS: (Troubleshoot defrost termination thermostat circuit using proper procedures outline in manufacturer's service manual, by instructor, or according to system design and electrical circuit schematic.)



PERFORMANCE STANDARDS:

- Test defrost termination thermostat to determine that it opens at 70 degrees and closes at ±10 degrees.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe location of defrost termination thermostat.
- Describe and demonstrate how to use the ohmmeter (VOM).
- Explain how the defrost cycle operates.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.07 REMOVE AND REPLACE THE DEFROST TERMINATION THERMOSTAT

---

PERFORMANCE OBJECTIVE:

Given a refrigerator with a faulty defrost termination thermostat and access to the proper tools, test equipment, and a replacement defrost termination thermostat; remove and replace the defrost termination thermostat. The defrost termination thermostat must be wired according to the manufacturer's diagram and must cycle the defrost heater on and off.

PERFORMANCE ACTIONS: (Remove and replace defrost termination thermostat according to manufacturer's service literature or acceptable servicing procedure.

PERFORMANCE STANDARDS:

- Remove and repalce the deforst termination thermostat according to the manufacturer's schematic and so the timer cycles the defrost heater on and off.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNCIAL INFORMATION:

- Describe the operation of defrost termination thermostat.
- Identify and select proper defrost termination thermostat for given refrigerators.
- Read and follow a schematic for a domestic refrigerator.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.08 TEST DEFROST TIMER

---

PERFORMANCE OBJECTIVE:

Given a refrigerator and the necessary test equipment, test the defrost timer. Determine if timer cycling is according to the manufacturer's specifications.

PERFORMANCE ACTIONS:

15.0801 Disconnect refrigerator from power outlet.

15.0802 Connect ammeter to one of the incoming power ines.

15.0803 Reconnect unit to electrical power.

15.0804 Turn defrost timer slowly until first click is encountered.

15.0805 On first click, ammeter should indicate amperage and the compressor should stop. The heating elements should be energized at this point.

15.0806 Observe timer to see if it advances out of defrost. (If timer does not advance in about 20 minutes, replace it.)

(ACTIONS MAY CONTINUE INTO NEXT TASK.)

PERFORMANCE STANDARDS:

- Test defrost timer to determine if it is cycling according to the manufacturer's specifications.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Describe how to measure resistance with the VOM.
- Explain the purpose of the defrost timer.
- Locate the defrost timer in a given refrigerator.
- Identify safety considerations.

TASK 15.09 TEST DEFROST HEATER

PERFORMANCE OBJECTIVE;

Given a refrigerator and the necessary test equipment, test the defrost heater. The heater will be open, shorted, grounded, or good.

PERFORMANCE ACTIONS: (ACTIONS MAY CONTINUE FROM PREVIOUS TASK)

15.0907 If no current increase is indicated after first click, disconnect refrigerator from line.

15.0908 Using ohmmeter, check continuity between contact points of timer. (If appropriate, clean and adjust points.)

15.0909 Check defrost thermostat for continuity (replace unit if necessary).

15.0910 Check heater element for continuity (repair or replace if defective).

15.0911 Check work.

PERFORMANCE STANDARDS:

- Test a defrost heater. The heater will be open, shorted, grounded, or good.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNCIAL INFORMATION:

- Describe how to use the VOM to measure resistance.
- Identify where the defrost heater is located.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.10 REPALCE A DEFROST HEATER

---

PERFORMANCE OBJECTIVE:

Given a refrigerator wiht a defective defrost heater, test equipment such as ammeter, mechanic's tools and equipment, defrost heater replacement, and other materials needed; remove and replace defrost heater. The new heater must be wired according to the unit schematic diagram and the freezer must defrost properly.

PERFORMANCE ACTIONS:

15.1001 Disconnect electrical power from refrigerator.

15.1002 Open freezer compartment door.

15.1003 Allow freezer compartment to warm up.

15.1004 Remove evaporator cover panel.

15.1005 Remove screws from evaporator mounting brackets.

15.1006 Carefully pull evaporator out enough to make defrost heater accessible.

15.1007 Disconnect defrost heater wiring.

15.1008 Remove heater from evaporator.

15.1009 Install new defrost heater in evaporator slots.

15.1010 Connect wiring. (Wiring should not touch heater.)

15.1011 Push evaporator back into position.

15.1012 Replace mounting screws.

15.1013 Have instructor check installation.

15.1014 Replace evaporator cover panel.

15.1015 Plug in refrigerator to wall outlet.

15.1016 Set temperature control at mid-range.

15.1017 Allow refrigerator to operate long enough to cool down the termination thermostat.

15.1018 Set ammeter at proper scale (highest).

15.1019 Place ammeter around line conductor.

PERFORMANCE ACTIONS (Con't.):

15.1020 Turn timer shaft in clockwise direction until first click.

15.1021 Check ammeter reading.

15.1022 Select ammeter scale for a center scale reading.

15.1023 Observe ammeter for reduction in reading when the termination thermostat opens.

15.1024 Check length of tme of defrost cycle (should not be longer than 25 minutes).

PERFORMANCE STANDARDS:

- Remove and replace defrost heater so that the unit is wired according to the manufacturer's schematic and the freezer operates in the defrost mode.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain the purpose of defrost heaters.
- Identify and select the proper defrost heater for a given refrigerator system.
- Identify safety considerations and precautions in installation (care in removing/replacing a heater with sharp finned evaporator, etc.).

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.11 DIAGNOSE AND REPAIR DOMESTIC REFRIGERATOR ELECTRICAL CIRCUITS

---

PERFORMANCE OBJECTIVE:

Given a domestic refrigerator and test equipment, tools and materials; diagnose and repair electrical circuits. Identify and correct shorts, opens, and grounds so the unit operates correctly.

PERFORMANCE ACTIONS:

15.1101 Check wiring diagram for unit (attached to rear panel, etc., of unit). If no diagram is available, sketch circuits and parts and indicate where new wiring is to be installed.

15.1102 Determine size and type of wire to be replaced. (Follow color codes if possible.)

15.1103 Cut new wire to proper length.

15.1104 Strip insulation off each end of wire without injuring metal.

15.1105 Install terminals on new wire. (Both wire and terminals must be clean.) Use same type terminals which are used on other wiring. Adequately tape terminals where appropriate.

15.1106 Install new wires tightly on cleaned proper terminals to complete all circuits.

15.1107 Check circuits for proper wiring and connections.

15.1108 Check to be sure all metal parts are grounded.

15.1109 Reconnect electrical system to power and check its operation and the operation of each control.

PERFORMANCE STANDARDS:

- Diagnose and repair domestic refrigerator electrical circuits by identifying and correcting all shorts, open, ground circuits.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNCIAL INFORMATION:

- Interpret symbols of electrical diagram/schematic.
- Explain electrical operation of refrigerator.
- Select and explain/demonstrate use of electrical test equipment.
- Read and follow diagram or schematic.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.11 DIAGNOSE AND REPAIR DOMESTIC REFRIGERATOR ELECTRICAL CIRCUITS

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PERFORMANCE ACTIONS (Con't.):

- Describe use of the ohmmeter; Use ohmmeter.
- Identify short and open circuits.
- Identify safety considerations.

## TASK NOTES

System, Make ____________________ Model ____________
Condensing Unit, Make ________ Model ________ Starting Amps ______
Running Amps ______ voltage ______ Phase ________
Hertx ________ Overload, Make ________ Type ______
Relay, Make ________ Type ______
Refrigerant Control ______________________________
Motor Control, Make ____________ Type ______ Location ________
System Accessories (Butter conditioner, etc.) ________________

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.12 LOCATE AND REPAIR AN EVAPORATOR LEAK

---

PERFORMANCE OBJECTIVE:

Given a evaporator with a leak, epoxy glue, and the necessary tools and materials; locate and repair the evaporator leak. The evaporator will not leak under pressure of 60 psi.

PERFORMANCE ACTIONS:

15.1201 Clean surface(s) to be bonded by sanding with clean, course sandpaper or clean steel wool.

15.1202 Clean surface with recommended solvents such as acetone, toluene, or a similar industrial solvent.

15.1203 Mix epoxy glue on a clean surface such as a piece of cardboard. Compounds should be mixed of equal parts until uniform color is obtained.

15.1204 Apply epoxy mixture to surface for a small hole or to mating surfaces if a patch is being used.

PERFORMANCE STANDARDS:

- Locate and repair an evaporator leak so the evaporator will not leak under pressure of 60 psi.

SUGGESTED INSTRUCITON TIME:

RELATED TECHNICAL INFORMATION:

- Describe/demonstrate the successful mixing of epoxy.
- Explain how to prepare and apply epoxy glue.
- Identify safety precautions.
- Identification of epoxies which are suitable for use with refrigerants R-12 and R-22.

UNIT 15.0 DOMESTIC REFRIGERATION

## TASK 15.13 CLEAN CAPILLARY TUBING

---

PERFORMANCE OBJECTIVE:

Given a refrigerator with restricted capillary tube, capillary tube cleaner, flat file, torch, sand cloth, silver brazing alloy, silver solder flux, 1/4 inch copper o.d., 1/4 inch flare nut, mechanic's tools, tubing cutter, and other required materials; clean capillary tubing. The capillary tubing must equalize and the unit must cycle.

PERFORMANCE ACTIONS:

15.1301 Straighten capillary tube. (No sharp turns to restrict particles.)

15.1302 Score capillary tube one inch from end with edge of flat file.

15.1303 Place pliers on capillary tube and break it.

15.1304 Cut about a 4 inch piece of 1/4 inch copper tubing.

15.1305 Flare one end of tubing just cut.

15.1306 Place flare nut on tubing.

15.1307 Polish capillary tube.

15.1308 Insert capillary tube into opposite end of tubing from flare.

15.1309 Crimp tubing.

15.1310 Silver braze tubing to capillary tube.

15.1311 Attach capillary tube cleaner to flare nut.

15.1312 Check hook up.

15.1313 Force oil through capillary tube.

15.1314 Remove cleaner (leave tubing connection if desired).

PERFORMANCE STANDARDS:

- Clean capillary tubing so that it equalizes and the unit cycles.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain operation of capillary tube cleaner.
- Identify safety considerations.

TASK EXPANSION:

1. If there are symptoms of moisture freeze-up, except for an accumulation of frost, check the capillary tube for a possible kink.
2. Replace a capillary tube (instructor to describe actions).

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.14 INSTALL INLINE SERVICE STUB

---

## PERFORMANCE OBJECTIVE:

Given a refrigerator, torch, sand cloth, silver brazing alloy, silver solder flux, shop towels, side cutters, tubing cutter, copper tubing, striker, sweat tee, and the necessary tools and materials; install an inline service stub using proper procedures and safety precautions. The service stub will not leak and will be long enough for pinch off after use.

## PERFORMANCE ACTIONS:

15.1401 Disconnect refrigerator from electrical power.

15.1402 Take safety precautions.

15.1403 Discharge refrigerant slowly. (Suction line may be cut for discharging.)

15.1404 Place "shop towel" under discharging refrigerant.

15.1405 Allow refrigerant charge to discharge before proceeding.

15.1406 Cut suction line with tubing cutter.

15.1407 Cut off short piece of clean tubing.

15.1408 Coat tubing ends with flux.

15.1409 Insert tubing into sweat tee.

15.1410 Light and adjust torch.

15.1411 Silver braze the three joints.

15.1412 Turn off torch.

15.1413 Clean brazed joints (using damp shop towel).

15.1414 Select valves that will be used.

15.1415 Discharge line.

15.1416 Seal end of service stub with valve or by crimping or brazing.

15.1417 Check work, clean up.

PERFORMANCE STANDARDS:

- Install inline service stub in a domestic refrigeration system so that the stub does not leak and is long enough for pinch off after use.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNCIAL INFORMATION:

- Identify safety considerations.
- Explain purpose of service stubs.
- Describe how to locate service stubs.
- Describe how to install a service stub.
- Identify various sizes of copper tees and tubing.
- Describe how to pinch off a service stub after use.

UNIT 15.0 DOMESTIC REFRIGERATION

## TASK 15.15 CHECK HERMETIC COMPRESSOR FOR PUMPING EFFICIENCY

---

PERFORMANCE OBJECTIVE:

Given a compressor and the necessary tools, test equipment and instruments, mechanic's tools, gauge set, line piercing valve, torch kit, pinch-off tool, ammeter, safety galsses, etc.; test the compressor for pumping efficiency. The compressor should pump no less than 25 inches of mercury vacuum while pumping 125 psi head pressure.

PERFORMANCE ACTIONS: (See addendum page)

15.1501 Identify the three methods to check pumping efficiency:
- a. Observing suction pressure.
- b. Pinch off suction line or disconnect lines from compressor.
- c. Check wattage at normal, low, and high pressure.

15.1502 Select most appropriate method for test.

15.1503 Observe safety precautions.

15.1504 Conduct test of compressor for pumping efficiency.

PERFORMANCE STANDARDS:

- Test compressor for pumping efficiency. The compressor will pump no less than 25 inches of mercury vacuum while pumping 125 psi head pressure.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify safety considerations.
- Use of gauge set, line piercing valve, torch kit, test instruments, mechanic's tools, etc.

## BASIC METHODS TO TEST COMPRESSOR FOR PUMPING EFFICIENCY

1. OBSERVE SUCTION PRESSURE:
   - a. Connect compound gauge to suction line using line piercing valve or refrigeration service valve kit.
   - b. Start compressor and run it for about 30 minutes.
   - c. Observe suction pressure (should be below 15 P.S.I.G. if efficient).

2. PINCH OFF OR DISCONNECT SUCTION LINE:
   - a. Install compound gauge on suction line side of compressor.
   - b. Pinch off suction line with pinch-off tool.
   - c. Start compressor. (Pull down to 25 to 27 inches of vacuum.)
   - d. Stop compressor (efficient compressor should hold vacuum for a few minutes).

3. WATTAGE CHECK:
   - a. Attach gauge set to system.
   - b. Connect ammeter and voltmeter (or wattmeter) to compressor terminals.
   - c. Start system.
   - d. Allow pressure to stabilize.
   - e. Observe electrical instrument scales (readings).
   - f. Compare with motor rating (plate tag, etc.) (Lower wattage than motor rating indicates poor efficiency).
   - g. Shut off system.

UNIT 15.0 DOMESTIC REFRIGERATION

## TASK 15.16 REMOVE AND REPLACE A HERMETIC COMPRESSOR

---

PERFORMANCE OBJECTIVE:

Given a refrigerator with a faulty compressor, and the necessary tools and equipment, brazing unit, and a replacement compressor; remove and replace the compressor. Brazed joints will be leakproof, wiring will be according to the schematic or diagram provided, and the compressor will be mounted securely and charged to spcifications. The unit should eperate as intended.

PERFORMANCE ACTIONS:

15.1601 Take safety precautions.

15.1602 Attach the valve attachment or clamp-on, purge lines and check for leaks.

15.1603 Purge refrigerant from system. (Ventilate service area). Trap oil mist.

15.1604 Remove electrical connections and overload protection and relay if mounted on the motor compressor.

15.1605 Cut refrigerant lines.

15.1606 Unbolt motor compressor and remove it.

15.1607 Tape or plug system lines to keep moisture and dirt out of system. Avoid touching oil (it may be acid).

15.1608 Pinch tubing stubs connected to motor compressor.

15.1609 Store removed compressor (for training use, etc).

15.1610 Replace compressor with equivalent unit following reverse procedures.

PERFORMANCE STANDARDS:

- Remove and replace a domestic refrigerator hermetic compressor, brazed joints will be leakproof, wiring the unit according to the diagram/schematic provided, and so the compressor is mounted securely and charged to specifications. The replaced compressor and system should operate as intended.

SUGGESTED INSTRUCTION TIME:

TASK 15.16 REMOVE AND REPLACE A HERMETIC COMPRESSOR (Con't.)

---

RELATED TECHNICAL INFORMATION:

- Describe how to test a hermetic compressor.
- Explain how to remove a hermetic compressor.
- Explain how to replace a hermetic compressor.
- Identify different types of compressors typical to domestic refrigerators.
- Describe how to read a schematic/diagram.
- Describe how to braze a leakproof joint.
- Identify safety considerations.

## SERVICE NOTES

System: Make ______________ Model__________ Serial # ____________
Type ______________
Condenser Line: Dia. ________ Suction Line _________
Process Tube ___________

EXAMINE THE CONSTRUCTION FEATURES OF GIVEN HERMETIC AND SEMI-HERMETIC COMPRESSORS:

Compressor No. ____

1. The name of the compressor is ____________________

2. The application of the compressor is ____________________

3. The type of compressor is (hermetic, semihermetic). ____________________

4. The compressor is (piston-type reciprocating, rotary). ____________________

5. The rotary type has (one, two, three, four) stationary blades. ____________________

6. The rotary type has (one, two, three, four) revolving blades. ____________________

7. Rpm of this compressor is ____________________

8. The displacement of this compressor is ____________________

9. The capacity of this compressor is ____________________

10. This compressor is designed for a (high-side float, capillary tube) as the refrigerant control. ____________________

11. The unloading device used is ([illegible], electrical, [illegible]). ____________________

12. The oiling system used is (forced feed, semiforced feed, splash). ____________________

13. The motor is a (split-phase, capacitor-start) type. ____________________

14. The motor winding insulation is (cotton, plastic). ____________________

15. The low-side of the compressor is to the (dome, direct piping). ____________________

16. This compressor, within the dome, is (spring mounted, stationary, other). ____________________

17. The compressor is designed for (R-12, R-22, other). ____________________

18. The compressor is cooled by (attached fins, forced air, other). ____________________

19. The terminals are (neoprene sealed, glass fused, other). ____________________

20. Draw a diagram in the space provided to show the location and notation of the terminals.

21. This compressor (does, does not) use a muffler. ____________________

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UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.17 (ORIENTATION) INSTALL REFRIGERATOR EQUIPPED WITH AN ICE MAKER

---

## PERFORMANCE OBJECTIVE:

Given a domestic refrigerator equipped with an ice maker, mechanic's tools, tubing cutter, 5/32" and 3/8" drill bits, 3/8" portable drill, water line saddle valve, role of 1/4 inch copper o.d. tubing, and other material needed; install the domestic refrigerator equipped with an ice maker.

## PERFORMANCE ACTIONS:

15.1701 Place refrigerator in proper location.

15.1702 Level refrigerator.

15.1703 Locate cold water supply line.

15.1704 Shut off water.

15.1705 Open hydrant to drain water line.

15.1706 Drill 5/32" hole in water line (if saddle valve is not self-taping).

15.1707 Place saddle valve on water line.

15.1708 Ensure inlet on valve is securely in hole in water line.

15.1709 Check that gasket is in place.

15.1710 Measure distance from water supply to water fill valve.

15.1711 Add additional four feet of tubing to be looped behind the refrigerator.

15.1712 Connect tubing to saddle valve.

15.1713 Make 3-4 loops in tubing behind refrigerator (so the refrigerator can be in and out for cleaning).

15.1714 Close valve stem on saddle valve.

15.1715 Turn on main water supply.

15.1716 Close hydrant that was opened to drain water line.

15.1717 Place container at end of water line.

TASK 15.17 INSTALL REFRIGERATOR EQUIPPED WITH AN ICE MAKER

---

PERFORMANCE ACTIONS (Con't.):

15.1718 Open valve on saddle valve.

15.1719 Allow small amount of water to run through line to flush it.

15.1720 Close valve stem on saddle valve.

15.1721 Connect water line to fill valve.

15.1722 Turn on saddle valve.

15.1723 Check for water leaks.

15.1724 Replace panels, etc., removed during installation.

15.1725 Check installation, clean up.

PERFORMANCE STANDARDS:

- Install refrigerator equipped with an ice maker so that the system works as designed and so there are no water leaks and no damage to house plumbing.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Tubing.
- Use of hand tools.
- Installation of saddle valve.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.18 ADJUST THE WATER LEVEL SWITCH ON ICE MAKER

---

PERFORMANCE OBJECTIVE:

Given a refrigerator ice-maker and the necessary tools and materials, adjust the water level. The water level will be no less than 1/4 inch form the top of the mold and will not overflow.

PERFORMANCE ACTIONS: (Actions depend on type of unit and make.)

(THESE ACTIONS GIVEN FOR FLEX-TRAY ICE MAKER WATER VALVE SWITCH)

15.1801 Manually start ice making cycle.

15.1802 Hold container under fill spout.

15.1803 Catch water as it is dispenses towards end of cycle.

15.1804 Check container (for about 200cc's of water in it).

15.1805 Remove plug on right side of ice maker.

15.1806 Insert screwdriver into adjusting screw slot.

15.1807 Turn adjusting screw (1 revolution = about 20 cc's).

15.1808 Check work.

15.1809 Clean up.

PERFORMANCE STANDARDS:

- Adjust water level switch on ice-maker so that the water level will be no less than 1/4 inch from the top of the mold and will not overflow.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Locate water level switch.
- Describe opening sequence of ice-maker.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.19 (ORIENTATION) REPLACE DEFECTIVE ICE MAKER

---

## PERFORMANCE OBJECTIVE:

Given a refrigerator, ice maker, and the necessary tools and materials; remove a defective ice maker and install a replacement unit. Electrical connections must be mechanically nad electrically secure and leads and connections must be wired according to the manufacturer's schematic, soldered ocnnections must form a tight seal and joints must be leakproof, and the water meter valve will flow according to the manufacturer's specifications.

## PERFORMANCE ACTIONS:

(Actions to be determined by type of ice maker and manufacturer's service manual.)

15.1901 Identify if unit is:
- a. Crescent-shaped ice maker.
- b. Five-cavity ice maker.
- c. Flex-tray ice maker.

15.1902 Orientation to ice maker problems, checks, and remedies (varies with type of unit and manufacturer).

15.1903 Orientation to electrical connections and circuit of each type of ice maker.

## PERFORMANCE STANDARDS:

- Replace defective ice maker. The replacement unit must have mechanically and electrically secure electrical connections wired according to the manufacturer's schematic. Joints must be sealed tight and leakproof. The water meter valve must flow according to manufacturer's specifications.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Demonstrate skill in reading schematics of refrigerators.
- Identify various types of compression fittings.
- Describe the operating sequence of an ice maker.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.20 REMOVE AND REPLACE A MOLD HEATER

---

PERFORMANCE OBJECTIVE:

Given a refrigerator with an ice maker and the necessary tools and materials, remove and replace a mold heater. The mold heater will heat the mold during the harvest cycle and be firmly in place.

PERFORMANCE ACTIONS: *

15.2001 "Remove front cover.

15.2002 "Remove ice maker.

15.2003 "Remove three mounting-plate-to-support-housing attaching screws.

15.2004 "Remove four mold-to-support-housing screws.

15.2005 "Detach thermostat from mold.

15.2006 "Detach mold heater from wire leads.

15.2007 "Separate mold from support housing.

15.2008 "Use flat-bladed screwdriver to pry inoperative heater from mold groove.

15.2009 "Clean remaining Alumilatic** from mold groove.

15.2010 "Apply layer of Alumilastic** in mold groove.

15.2011 "Install replacement mold heater. Thread screws supplies with replacement heater into holes provided in mold to secure heater in place.

15.2012 "Replace parts in reverse order from removal. Be sure the thermostat gasket is in place. Bond thermostat to mold with Alumilastic**."

* - Actions taken from:

Miller, Rex, Refrigeration and Air Conditioning Technology, Peoria, IL: Bennett Publishing Co., 1983.

** - Or equivalent material.

PERFORMANCE STANDARDS:

- Remove and replace mold heater. The mold heater will heat the mold during the harvest cycle and be firmly mounted in place.

TASK 15.20 REMOVE AND REPLACE A MOLD HEATER (Con't.)

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Locate mold heaters.
- Describe the operating sequence of ice makers.
- Identify safety considerations.

UNIT 15.0 DOMESTIC REFRIGERATION

TASK 15.21 TROUBLESHOOT A DOMESTIC REFRIGERATOR OR FREEZER

---

### PERFORMANCE OBJECTIVE:

Given a refrigerator with a possible malfunction, mechanic's tools and equipment, VOM and amprobe, gauge set and refrigerant as needed, and other required parts nad supplies; troubleshoot and repair a domestic refrigerator or freezer (if assigned) so that problem is properly identified and the unit is repaired if possible. Performance must be to the instructor's standards.

### PERFORMANCE ACTIONS:

15.2101 Assemble tools and equipment at malfunctioning refrigerator.

15.2102 Troubleshoot unit according to accepted procedures.*
* - Use "troubleshooting chart" if available.

15.2103 Check diagnosis.

15.2104 Check repairs.

15.2105 Return unit to normal service or make recommendations.

### PERFORMANCE STANDARDS:

- Troubleshoot a given domestice refrigerator (freezer) using materials, parts, tools, etc., provided by the instructor. Proper troubleshooting procedures, servicing and repair techniques, and safety procedures must be demonstrated to the instructor's standards.

### SUGGESTED INSTRUCTION TIME:

### RELATED TECHNICAL INFORMATION:

- Use of VOM, Amprobe.
- Use of Refrigeration Servicing instruments and gauges.
- Proper use of mechanic's tools and equipment.
- Basic refrigeration system servicing skills.
- Basic refrigeration system servicing knowledge.

# Domestic Refrigeration
# TROUBLESHOOTING CHART

| TROUBLE | COMMON CAUSE | REMEDY |
|---|---|---|
| 1. Unit will not run. | Blown fuse. | Replace fuse. |
| | Low voltage. | Check outlet with voltmeter, should check 115V plus or minus 10 percent. |
| | | If circuit overloaded, either reduce load or have electrician install separate circuit. |
| | | If unable to remedy any other way, install auto-transformer. |
| | Broken motor or temperature control. | Jumper across terminals of control. If unit runs and connections are all tight, replace control. |
| | Broken relay. | Check relay, replace if necessary. |
| | Broken overload. | Check overload, replace if necessary. |
| | Broken compressor. | Check compressor, replace if necessary. |
| | Defective service cord. | Check with test light at unit; if no circuit and current is indicated at outlet, replace or repair. |
| | Broken lead to compressor, timer or cold control. | Repair or replace broken leads. |
| | Broken timer. | Check with test light and replace if necessary. |
| 2. Refrigerator section too warm. | Repeated door openings. | Instruct user. |
| | Overloading of shelves, blocking normal air circulation in cabinet. | Instruct user. |
| | Warm or hot foods placed in cabinet. | Instruct user to allow foods to cool to room temperature before placing in cabinet. |
| | Poor door seal. | Level cabinet, adjust door seal. |
| | Interior light stays on. | Check light switch; if faulty, replace. |
| | Refrigerator section airflow control. | Turn control knob to colder position. Check air flow heater. |
| | | Check if damper is opening by removing grille. With door open, damper should open. If control inoperative, replace control. |
| | Cold control knob set at too warm a position, not allowing unit to operate often enough. | Turn knob to colder position. |
| | Freezer section grille not properly positioned. | Reposition grille. |
| | Freezer fan not running properly. | Replace fan, fan switch, or defective wiring. |
| | Defective intake valve. | Replace motor compressor. |
| | Air duct seal not properly sealed or positioned. | Check and reseal or put in correct position. |
| 3. Refrigerator section too cold. | Refrigerator section airflow control knob turned to coldest position. | Turn control knob to warmer position. |
| | Airflow control remains open. | Remove obstruction. |
| | Broken airflow control. | Replace control. |
| | Broken airflow heater. | Replace heater. |
| 4. Freezer section and refrigerator section too warm. | Fan motor not running. | Check and replace fan motor if necessary. |
| | Cold control set too warm or broken. | Check and replace if necessary. |
| | Frozen evaporator blocked with ice. | Check defrost heater thermostat or timer. Either one of these could cause this condition. |
| | Shortage of refrigerant. | Check for leak, repair, evacuate and recharge system. |
| | Not enough air circulation around cabinet. | Relocate cabinet or provide clearance to allow sufficient circulation. |
| | Dirty condenser or obstructed condenser ducts. | Clean the condenser and the ducts. |
| | Poor door seal. | Level cabinet, adjust door seal. |
| | Too many door openings. | Instruct customer. |
| 5. Freezer section too cold. | Cold control knob improperly set. | Turn knob to warmer position. |
| | Cold control capillary not properly clamped to evaporator. | Tighten clamp or reposition. |
| | Broken cold control. | Check control. Replace if necessary. |

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| TROUBLE | COMMON CAUSE | REMEDY |
|---|---|---|
| 6. Unit runs all the time. | Not enough air circulation around cabinet or air circulation is restricted. | Relocate cabinet or provide proper clearances around cabinet--remove restriction. |
| | Poor door seal. | Check and make necessary adjustments. |
| | Freezing large quantities of ice cubes, or heavy loading after shopping. | Explain to customer that heavy loading causes long running time. |
| | Refrigerant charge. | Undercharge or overcharge--check, evacuate and recharge with proper charge. |
| | Room temperature too warm. | Ventilate room as much as possible. |
| | Cold control. | Check control; if it allows unit to operate all the time, replace control. |
| | Defective light switch. | Check if light goes out. Replace switch if necessary. |
| | Excessive door openings. | Instruct customer. |
| 7. Noisy operation. | Loose flooring or floor not firm. | Tighten flooring or brace floor. |
| | Tubing contacting cabinet or other tubing. | Move tubing. |
| | Cabinet not level. | Level cabinet. |
| | Drip tray vibrating. | Move tray--place on styrofoam pad if necessary |
| | Fan hitting liner or mechanically grounding. | Move fan. |
| | Compressor mechanically ground. | Replace compressor mounts. |
| 8. Unit cycles on overload. | Broken relay. | Replace relay. |
| | Weak overload protector. | Replace overload protector. |
| | Low voltage. | Check outlet with voltmeter. Underload voltage should be 115V plus or minus 10 percent. Check for several appliances on same circuit or extremely long or under-sized extension cord being used. |
| | Dead compressor. | Check with test cord and also for ground before replacing. |
| 9. Stuck motor compressor. | Broken valve. | Replace motor compressor. |
| | Insufficient oil. | Add oil; if unit still will not operate, replace motor compressor. |
| | Overheated compressor. | If compressor faulty for any reason, replace motor compressor. |
| 10. Frost or ice on finned evaporator. | Broken timer. | Check with test light and replace if necessary. |
| | Defective defrost heater. | Replace heater. |
| | Defective thermostat. | Replace thermostat. |
| 11. Ice in drip catcher. | Defective drip catcher heater. | Replace heater. |
| 12. Unit runs all the time, temperature normal. | Ice builds up on the evaporator. | Check door gaskets--replace if necessary. |
| | Control bulb on thermostat not in contact with evaporator surface. | Place control bulb in contact with the evaporator surface. |
| 13. Freezer runs all the time. Temperature too cold. | Faulty thermostat. | Check thermostat--test and replace if necessary. |
| 14. Freezer runs all the time. Temperature too warm. | Ice buildup in insulation. | Remove breaker strips, warm unit, melt ice and dry insulation, seal outer shell leaks and joints and then assemble. |
| 15. Rapid ice buildup on the evaporator. | Leaky door gasket. | Adjust door hinges. Replace door gasket if cracked, brittle or worn. |
| 16. Door on freezer compartment freezes shut. | Faulty electric gasket heater. | Use alternate gasket heater or install new one. |
| | Faulty gasket seal. | Inspect and check gasket. If worn, cracked or hardened, replace it. |
| 17. Freezer works then warms up. | Moisture in refrigerator. | Install drier in liquid line. |
| 18. Gradual reduction in freezing capacity. | Wax buildup in capillary tube. | Use capillary tube cleaning tool or replace capillary tube. |

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## UNIT 16.0

## INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER

This mini-unit is designed to preceed the following unit concerning window/room air conditioners. This mini-unit may stand alone for instruction or may be integrated into the next unit as the instructor prefers.

Additional tasks concerning electrical wiring may be included to expand the student's knowledge and skills.

The tasks included are samples of what the air conditioning mechaninc should be prepared to accomplish during the installation of window/room air conditioning units.

# HVAC
# INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 16.0 | INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER | |
| 16.01 | Install Octagon Outlet Boxes | * |
| 16.02 | Rough in Cable for Circuit | * |
| 16.03 | Connect/Install 120V Receptacle Outlets | * |
| 16.04 | Connect Three-Wire 240 Volt Receptacle | * |
| 16.05 | Connect 120/240 Circuits to Circuit Breaker Panel Using Non-Metallic Cable | * |

* - No Time Estimated for Unit:
(Integrated with follwing unit.)

# TASK LISTINGS
# HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 16.0 | INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER |
| 16.01 | (INSTALL OCTAGON OUTLET BOXES) Given octagon outlet box, electrical plans, basic tool kit, and installation/electrical materials; install octagon outlet box. Outlet box must be mounted securely to structure, located according to plan or need and installed according to the National Electrical Code. |
| 16.02 | (ROUGH-IN CABLE FOR AC CIRCUIT) Given electrical drawing, basic tool kit, installation/electrical materials; rough-in cable for air conditioning circuit. Installation must be completed without damage to interior finish. Wire size must be appropriate for load to be served and cable must extend from power source to outlet box of load served and must be terminated in approved fittings. Installation must meet NEC. |
| 16.03 | (CONNECT/INSTALL 120V RECEPTACLE OUTLETS) Given 120V receptacle outlet, power source, previously roughed in wiring, basic tool kit, and installation/electrical mateirals; connect/install 120V receptacle outlet. Connections must be appropriate methods and with connectors suitable for purpose. Finished outlet must have correct polarity. Cover plate must be installed straight, must cover opening, and fit flush to wall. Receptacles must be mounted in a manner to present a uniform appearance. Receptacle outlet installation must meet NEC (Ar. 200-10, 200-11) and be to instructor's (contractor's) standards. |
| 16.04 | (CONNECT THREE-WIRE 240 VOLT RECEPTACLE) Given three-wire 240 (220,230 or 240) volt AC receptacle, power source, previously roughed in wiring, box, basic tool kit, and installation/electrical materials; connect three-wire 240 volt wall receptacle. Connections must be made using materials and conductors required by specifications and the NEC, with the wired receptacle supplied with the correct voltage and polarity. |
| 16.05 | (CONNECT 120/240 CIRCUITS TO CIRCUIT BREAKER PANEL USING NON-METALLIC CABLE) Given previously roughed-in non-metallic cable to circuit breaker panel for 120/240 volt circuits, breaker panel with circuit breakers, basic tool kit, and installation materials; connect 120/240 volt circuits to circuit breaker panel. Cable must enter panel through approved type connectors. Circuit conductors must be attached to correct size breaker. |

UNIT 16.0 INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER

TASK 16.01 INSTALL OCTAGON OUTLET BOX

---

PERFORMANCE OBJECTIVE:

Given octagon outlet box, electrical plans, basic tool kit, and installation/electrical materials; install octagon outlet box. Outlet box must be mounted securely to structure, located according to plan or need and installed according to the National Electrical Code.

PERFORMANCE ACTIONS:

16.0101 Review plan.

16.0102 Determine box needed. Obtain box and materials.

16.0103 Locate installation points.

16.0104 Attach octagon outlet box to structure.

PERFORMANCE STANDARDS:

- Install octagon outlet box as required according to requirements of NEC, and meeting instructor's standards for process and product.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Reading electrical plan.
- Identification of electrical device box.
- Locating box.
- Installation of box.

| | |
|---|---|
| UNIT 16.0 | INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER |
| TASK 16.02 | ROUGH IN CABLE FOR AC CIRCUIT |

---

PERFORMANCE OBJECTIVE:

Given electrical drawing, basic tool kit, installation/electrical materials; rough in cable for air conditioning circuit. Installation must be completed without damage to interior finish. Wire size must be appropriate for load to be served and cable must extend from power source to outlet box of load served and must be terminated in approved fittings. Installation must meet NEC.

PERFORMANCE ACTIONS:

| | |
|---|---|
| 16.0201 | Review drawing. |
| 16.0202 | Assemble materials. |
| 16.0203 | Determine location for installation of cable. |
| 16.0204 | Remove knockout or provide opening for boxes. |
| 16.0205 | Install cable connector (or conduit connector). |
| 16.0206 | Pull cable for circuit (or run conduit and pull cable). |
| 16.0207 | Fasten cable, etc., as required to meet code. |

PERFORMANCE STANDARDS:

- Rough in cable for AC circuit so that installation does not damage interior finish and cable is appropriate for load to be served and installation must meet NEC.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Read electrical drawing.
- Install cable/conduit.

UNIT 16.0 INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER

TASK 16.03 CONNECT/INSTALL 120V RECEPTACLE OUTLETS

---

PERFORMANCE OBJECTIVE:

Given a 120V receptacle outlet, power source, previously roughed in wiring, basic tool kit, and installation/electrical materials; connect/install 120V receptacle outlets. Connections must be by appropriate methods and with connectors suitable for purpose. Finished outlet must have correct polarity. Cover plate must be installed straight, must cover opening, and fit flush to wall. Receptacles must be mounted in a manner to present a uniform appearance. Receptacle outlet installation must meet NEC (Ar. 200-10, 200-11) and be to instructor's (contractor's) standards.

PERFORMANCE ACTIONS:

16.0301 Locate installation point.

16.0302 Turn power off.

16.0303 Using electrical test instrument, verify that power is off.

16.0304 Cut conductor at wall box to leave 6 inches of free conductor.

16.0305 Remove about 3/4 inch of insulation from each wire.

16.0306 Connect white conductors to silver or white terminals of device.

16.0307 Connect black conductor to brass or gold colored terminals.

16.0308
- a. Grounding conductors must be securely connected together using approved means and fastened to receptacle and to box as required.
- b. For metal box, connect green grounding conductors to wall box.

16.0309 Fasten outlet to wall box.

16.0310 Install cover plate.

16.0311 Turn power on. (When circuit installation completed)

16.0212 Check for correct polarity. (When circuit installation completed)

TASK 16.03 CONNECT/INSTALL 120V RECEPTACLE OUTLETS (Con't.)

---

PERFORMANCE STANDARDS:

- Connect or install duplex receptacle outlets on 120 circuit, according to NEC, so that polarity is observed and finsihed installation (plate) is flush with wall, aligned, uniformed in appearance, and to instructor's standards.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Safety.
- Polarity testing.

UNIT 16.0 INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER

TASK 16.04 CONNECT THREE-WIRE 240 VOLT RECEPTACLE

---

PERFORMANCE OBJECTIVE:

Given three-wire 240 (220, 230, 240) volt AC receptacle, power source, previously roughed in wiring, box, basic tool kit, and installation/electrical materials; connect three-wire 240 volt wall receptacle. Connections must be made using materials and conductors required by specifications and the NEC with the wired receptacle supplied with the correct voltage and polarity.

PERFORMANCE ACTIONS:

16.0401 Review plans, specifications.

16.0402 Locate installation point.

16.0403 Assemble materials.

16.0404 Turn power off.

16.0405 Using electrical instrument, verify that power is off.

16.0406 Cut conductor at wall box to leave 6 inches of free conductor.

16.0407 Remove approximately 3/4 inch insulation from each conductor.

16.0408 Connect grounding conductor (green or bare) to proper grounding terminal.

16.0409 Connect one of the line conductors to the brass (gold) terminal.

16.0410 Connect remaining line conductor to other brass (gold) terminal.

16.0411 Attach receptacle to wall box.

16.0412 Install cover plate.

16.0413 Turn power on.

16.0414 Check for proper voltage and polarity. (When circuit installation completed)

TASK 16.04 CONNECT THREE-WIRE 240 VOLT RECEPTACLE (Con't.)

---

PERFORMANCE STANDARDS:

- Connect three-wire 240 volt wall receptacle according to specificatons and NEC supplied with the proper voltage and polarity.

SUGGESTED INSTRUCTION TIME:

**UNIT 16.0** INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER

**TASK 16.05** CONNECT 120/240 CIRCUITS TO CIRCUIT BREAKER PANEL USING NON-METALLIC CABLE

---

## PERFORMANCE OBJECTIVE:

Given previously roughed in non-metallic cable to circuit breaker panel for 120/240 volt circuits, breaker panel with circuit breakers, basic tool kit, and installation/electrical materials; connect 120 and 240 volt circuits to circuit breaker panel. Cables must enter panel through approved type connectors. Circuit conductors must be attached to correct size breaker.

## PERFORMANCE ACTIONS:

16.0501 Review plans and specifications.

16.0502 Locate SEP.

16.0503 Turn power off.

16.0504 With electrical instrument, verify that power is off.

16.0505 Enter cables in SEP through approved connectors.

16.0506 Remove outer jacket from each cable to where the cable enters the SEP.

16.0507 Identify each cable as to circuit it serves.

16.0508 Identify conductors in each cable.

(NOTE: If two-wire cables are to serve 240 volt circuits, the white wire should be taped with black electrical tape to indicate it is a hot line conductor (or it may be marked red).)

16.0509 Connect all bare of green grounding conductors to the grounding terminal bar.

16.0510 Connect 120 volt circuit white conductors to neutral bar.

16.0511 Connect all 120 volt circuit black conductors to single pole breakers of correct ampacity.

UNIT 16.0 INSTALL ELECTRICAL OUTLET FOR WINDOW AIR CONDITIONER

TASK 16.05 CONNECT 120/240 CIRCUITS TO CIRCUIT BREAKER PANEL USING NON-METALLIC CABLE

---

PERFORMANCE ACTIONS (Con't.):

16.0512 Connect 240 volt circuits to double pole breakers of correct ampacity.

(NOTE: Any split receptacle 240 volt lines should be on double pole breakers for safety.)

16.0513 Check installation for shorts/grounds (Using VOM or other electrical instrument.

16.0514 After all circuits have checked satisfactory, attach SEP cover.

16.0515 Turn power on.

16.0516 Check each circuit for proper voltage/polarity.

PERFORMANCE STANDARDS:

- Connect 120/240 volt circuits to circuit breaker panel (SEP) using non-metallic cable roughed in through approved connectors.
- Circuits must be protected by proper ampacity breakers and installation must provide proper voltage/polarity as required and meet NEC.

SUGGESTED INSTRUCTION TIME:

# UNIT 17.0

## ROOM/WINDOW AIR CONDITIONERS

The purpose of this unit concerning room/window air conditioner units is to introduce the secondary student to applied basics of refrigeration and cooling as applied in room AC units and to provide the student with experience in installation, servicing, and troubleshooting room/window air conditioners.

Room air conditioner tasks may overlap with basic refrigeration, air conditioning test instruments and equipment, or other units of learning in this guide. Installing electrical outlets for room air conditioners, while included in this unit, is covered in more detail in the previous mini-unit concerning electrical installations in residential structures.

Upon completing this unit, the student should be competent to install, service, and repair room/window air conditioners.

# HVAC
# ROOM/WINDOW AIR CONDITIONERS
# SUGGESTED INSTRUCTION TIMES

| HVAC UNIT/TASK | | SUGGESTED HOURS |
|---|---|---|
| Unit 17.0 | ROOM/WINDOW AIR CONDITIONERS | |
| 17.01 | Install/Wire AC Receptacle | * |
| 17.02 | Install AC Unit in Standards Sash-Type Window (ORIENTATION) | * |
| 17.03 | Install Window Ac Unit in Wall (ORIENTATION) | * |
| 17.04 | Check Window Unit for Cooling Capacity | * |
| 17.05 | Clean Window Air Conditioner Unit | * |
| 17.06 | Locate and Repair Refrigerant Leak | * |
| 17.07 | Repair Restriction in Line | * |
| 17.08 | Change Inoperative Compressor | * |
| 17.09 | Remove and Replace Fan Motor | * |
| 17.10 | Check Electrical System of Room AC Unit Compressor | * |
| 17.11 | Rewire Window AC Unit | * |
| 17.12 | Test Selector and Fan Speed Switches | * |
| 17.13 | Check Thermostat | * |
| 17.14 | Install a Hard Start Kit | * |
| 17.15 | Troubleshoot Window Unit | * |
| | Total Hours - | 30 |

* - Total Time Estimated

## TASK LISTINGS
## HVAC

| UNIT/TASK | DESCRIPTION |
|---|---|
| Unit 17.0 | ROOM/WINDOW AIR CONDITIONERS |
| 17.01 | (INSTALL/WIRE AC RECEPTACLE) Given circuit requirements for a window air conditioner, access to the current National Electrical Code and local codes (NEC guides local codes in Greenville, SC), necessary wire, outlet boxes and recpetacles, wiring information concerning structure, and necessary tools and materials; install/wire a 120 or 240 volt receptacle capable of handling the load and according to the NEC. |
| 17.02 | (INSTALL AC UNIT IN STANDARDS SASH-TYPE WINDOW) Given a standards sash-type window of the proper size, type, and condition, a window AC unit, electrical outlet suitable for the load, tool box with hand tools, sealing compound and insulation tape (in addition to material supplied with the new unit), manufacturer's installation instruction, and helper if needed; install the window air conditioner in the standard sash-type window. The installation must meet the manufacturer's recommendations, must be firmly attached to the structure, properly sealed/insulated, tilted slightly to the outside for proper drainage, and connected to an electrical outlet suitable for the oad. |
| 17.03 | (INSTALL WINDOW AC UNIT IN WALL) Given a window air conditioning unit, electrcial outlet suitable for the load, necessary hand tools, necessary power tools for installation, sealing compound and insulation material, manufacturer's installation instructions, helper as needed, and a wall to receive the AC unit; install the window AC unit in the wall so that it is firmly supported/attached, tilted slightly to the outside , and properly dressed for appearance on the inside. The completed installation should not result in damage to the structure and should appear professional. |
| 17.04 | (CHECK WINDOW UNIT FOR COOLING CAPACITY) Given a window AC unit, mechanic's tools, thermometer, ammeter, sling psychrometer, and other materials needed; check window unit for cooling capacity. Determine if unit is at its leak cooling capacity for the load capacity of the room. |

17.05 (CLEAN WINDOW AIR CONDITIONER UNIT) Given a window air conditioner and the necessary cleaning materials and tools: clean the unit so that air will pass through the evaporator and condenser unimpeded.

17.06 (LOCATE AND REPAIR REFRIGERANT LEAK) Given a room air conditioner, gauge manifold and hoses, thermometer, vacuum pump, leak detector, wiping cloth, safety goggles, and mechanic's tools as needed; locate and repair refrigerant leak. The unit must hold pressure when repaired.

17.07 (REPAIR RESTRICTION IN LINE) Given room air conditioner, gauge manifold and hoses, thermometer, vacuum pump, leak detector, wiping cloth, safety goggles, and mechanic's tools; diagnose and repair a restriction in the line. Unit must operate properly after repair.

17.08 (CHANGE INOPERATIVE COMPRESSOR) Given room AC unit, gauge manifold set, thermometer, vacuum pump, leak detector, safety goggles, wiping cloth, mechanic's tools and equipment, and other materials as needed; diagnose inoperative compressor, and remove and replace inoperative compressor. Repaired unit must operate satisfactorily and performance must be to instructor's standards.

17.09 (REMOVE AND REPLACE FAN MOTOR) Given room air conditioner unit, mechanic's tools and all necessary materials; remove and replace a fan motor. The replaced fan motor will run in the correct direction, the blades will not strike any metal, the electrical connections will be tight and secure, and the unit will operate satisfactorily.

17.10 (CHECK ELETRICAL SYSTEM OF ROOM AC UNIT COMPRESSOR). Given a room AC unit, mechanic's tools, ohmmeter, and unit diagram/schematic (or make drawing of electrical connections); check out electrical system of compressor.

17.11 (REWIRE WINDOW AC UNIT) Given a room air conditioner, access to proper tools and materials, rewire a window air conditioner correctly according to the wiring diagram provided. The rewired unit must operate properly (electrically).

17.12 (TEST SELECTOR AND FAN SPEED SWITCHES) On a given window air conditioning unit test the condition of the selector switch using the tools, ohmmeter, and materials supplied. The condition will either be open, shorted, or not sequenced correctly.

17.13 (CHECK THERMOSTAT) Given an ohmmeter, mechanic's tools, thermometer, ice water, and room AC unit or thermostat from room AC unit; check thermostat.

17.14 (INSTALL A HARD START KIT) Given a window air conditioning unit and access to the proper tools, install a hard start kit so that the unit will start properly.

17.15 (TROUBLESHOOT WINDOW UNIT) Given a window air conditioner, customer complaint concerning operation of the unit, AC mechanic's tools and equipment as needed, test instruments, supplies, and replacement parts as needed; troubleshoot the window air conditioning unit and restore it to service.

TASK 17.01 INSTALL/WIRE AC RECEPTACLE

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PERFORMANCE OBJECTIVE: (See previous mini-unit concerning electrical installations.)

Given circuit requirements for a window air condition, access to the current National Electrical Code and local codes (NEC guides local codes in Greenville, SC), necessary wire, outlet boxes and receptacles, wiring information concerning structure, and necessary tools and materials; install and wire a 120 and 240 volt receptacle capable of handling the load and according to the NEC.

(NOTE: If required by local code, arrange for electrician to install receptacle, if installer is not licensed for electrical work.)

PERFORMANCE ACTIONS:

| | |
|---|---|
| 17.0101 | Determine circuit requirements: 120 or 240 VAC and current load, receptacle type, etc. |
| 17.0102 | Inspect electrical circuits of structure. |
| 17.0103 | Plan circuit installation to balance load. |
| 17.0104 | Assemble wire, tools, and materials. |
| 17.0105 | Rough in outlet box, conductors, etc. |
| 17.0106 | Trim receptacle and make connections to distribution panel (Install switchbox, fuses,etc., as required). |
| 17.0107 | Check circuit for proper voltage and polarity. |

PERFORMANCE STANDARDS:

- Install and wire a receptacle for 120 and 240 volts as required by a given window AC unit. Check circuit and balance load. Install wire to current NEC codes and local codes. Installation must provide proper voltage and current for load. Polarity must be correct. Performance must meet instructor's standards. No damage must result to structure or electrical system.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identify load requirements of unit: 120/240 VAC and current demand (from Data Plate or Instructions).
- Determine wire/breaker size.
- Explain how to balance a load.
- Describe/demonstrate positioning outlet locations and circuit run.

RELATED TECHNICAL INFORMATION (Con't.):

- Demonstrate installation of boxes, receptacles, and connections to circuit breaker panel or switch box.
- Identify National Electrical Code requirements.
- Explain how to check electrical circuit installation, including polarity check.

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.02 (ORIENTATION) INSTALL AC UNIT IN STANDARD SASH-TYPE WINDOW

---

## PERFORMANCE OBJECTIVE:

Given a standard sash-type window of the proper size, type, and condition, a window AC unit, electrical outlet suitable for the load, tool box with hand tools, sealing compound and insulation tape (in addition to material supplied with new unit), manufacturer's installation instruction, and helper if needed; install the window air conditioner in the standards sash-type window. The installation must meet the manufacturer's recommendations, must be firmly attached to the structure, properly sealed/ insulated, tilted slightly to the outside for proper drainage, and connected to an electrical outlet suitable for the load.

## PERFORMANCE ACTIONS:

17.0201 Remove new unit from shipping carton. Carefully remove any tape or holding agent holding front grill in place. Remove screws, etc., and save them. Remove and place front grill out of way.

17.0202 Remove shipping angles, etc.

17.0203 Slide unit out of shell (if so designed).

17.0204 Install shell (or unit) by centering it in window with sill channel positioned against window stool.

17.0205 Pull sindow sash down behind angle on top of shell (unit cabinet) to hold shell in place.

1[illegible]0206 Insert screw in sill channel at bottom of window (NOTE: Actions depend on size and design of window unit.).

17.0207 Install small angle clamp in each of bottom channels, but, don't tighten screw fully.

17.0208 Position sliding curtains (panels) at each side until window space is filled (unit is centered).

17.0209 Hold each curtain (panel in place with clamping device provided.

17.0210 Ensure a tight seal between window and unit, block window sash in place (screws, etc.) so window can not be raised.

TASK 17.02 INSTALL AC UNIT IN STANDARD SASH-TYPE WINDOW

---

PERFORMANCE ACTIONS (Con't.):

17.0211 Install gasket foam along edges to seal/insulate unit.

17.0212 Check to see that shell is tilted 1/2 bubble on level to rear for correct tilt.

17.0213 Install unit in shell (if unit separate from shell).

17.0214 Plug into receptacle designed for unit load.

17.0215 Check unit for proper fan and blower alignment/ operation.

17.0216 Complete installation, clean up, and leave instruction materials with owner.

PERFORMANCE STANDARDS:

- Install AC unit in standard sash-type window so that unit is centered, properly fastened to sash-stool, sealed/insulated, tilted slightly to outside, and connected to a receptacle designed for the load. Unit must operate properly. Performance must be to the instructor's standards.

SUGGESTED INSTRUCTION TIMES:

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.03 INSTALL WINDOW AC UNIT IN WALL

---

PERFORMANCE OBJECTIVE:

Given a window air conditioning unit, electrical outlet suitable for the load, necessary hand tools, necessary power tools for installation, sealing compound and insulation material, manufacturer's installation instructions, helper as needed, and a wall to receive the unit; install the AC unit in the wall so that it is firmly supported/attached, tilted slightly to the outside, and properly dressed for appearance on the inside. The completed installtion should not result in damage to the structure and should appear professional.

PERFORMANCE ACTIONS:

17.0301 Remove unit from shipping carton and prepare a unit for installtion.

17.0302 Measure wall opening required to house unit. Determine location of unit support braces, etc.

17.0303 Cut opening in wall to house unit. Take care not to damage wall (cause crack in cement or brick joints, etc.).

17.0304 Place shell in wall opening with front edge protruding into room about 3/4 inch from inside wall surface. Check placement of grillwork so allowance is correctly measured.

17.0305 Square shell with wall and secure shell to wall with suitable fasteners. (Prepare holes in shell as necessary.)

17.0306 Shim cracks between sides of shell and opening with appropriate material, as needed.

17.0307 Seal unit appropriately.

17.0308 Check work and ensure that installation meets codes.

PERFORMANCE STANDARDS:

- Install window AC unit in given wall. Wall opening must be properly measured to house unit without excess space, unit must be firmly attached to structure and tilted slightly outward. Unit must be properly shimmed and sealed. No damage should result to structure (cracks in block or brick joint, split wood, etc.). Unit must be connected to a receptacle designed for the load. Unit must operate properly.

SUGGESTED INSTRUCTION TIME:

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.04 CHECK WINDOW UNIT FOR COOLING CAPACITY

---

## PERFORMANCE OBJECTIVE:

Given a window AC unit, mechanic's tools, thermometer, ammeter, sling psychrometer, and other materials needed; check window unit for cooling capacity. Determine if unit is at its peak cooling capacity for the load capacity of the room.

## PERFORMANCE ACTIONS: (2 Methods)

17.0401 Determine best method for checking efficiency of unit cooling capacity.

a. Measure difference between air into unit and air from evaporator coil.
b. Measure amperage of unit and check reading against data plate.

(FIRST METHOD)

17.0402 Run room AC unit for about 10-15 minutes.

17.0403 Take temperature of air entering cooling coil (evaporator).

17.0404 Take temperature of air leaving evaporator.

17.0405 Take relative humidity factor of room.

17.0406 Calculate "split or temperature differential". (Should be between 15-20 degrees F)

(SECOND METHOD)

17.0407 Take amperage of unit running.

17.0408 Check full load amps on data plate.

17.0409 Determine if current measured is near rating on data plate.

## PERFORMANCE STANDARDS:

- Check window unit for cooling capacity using both methods. Determine if the unit is operating efficiently.

## SUGGESTED INSTRUCTION TIME:

---

RELATED TECHNICAL INFORMATION:

- Use of ammeter.
- Use of thermometer.
- Use of sling psychrometer.
- Higher relative humidity lowers split (cooling power goes to latent heat removal...changing vapor to water on cooling coil) instead of sensible heat removal (lowering temperature of air).
- Calculations.
- Use of hand calculators (dial-a-fix, etc.).

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.05 CLEAN WINDOW AIR CONDITIONER UNIT

---

PERFORMANCE OBJECTIVE:

Given a window air conditioner and the necessary cleaning materials and tools; clean the unit so that air will pass through the evaporator and condenser unimpeded.

PERFORMANCE ACTIONS: (Instructor will outline acceptable procedures.)

17.0501 Unit may be very carefully removed from window and placed on ground.

17.0502 If appropriate, cover may be removed from unit.

17.0503 Condensor and evaporator units may be sprayed with "Fantastic", "Formula 409", or a similar cleaner, and then washed with slight pressure.

17.0504 Straighten bent fins.

17.0505 Waterproof unit and check electrical connections, etc.

17.0506 Replace cover.

17.0507 Install unit and test operation.

PERFORMANCE STANDARDS:

- Clean window air conditioner unit condenser and evaporator using acceptable techniques so that no damage results to unit and so that air passes through evaporator and condenser unimpeded.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain procedures for removing a window AC unit.
- Explain procedure for straightening condenser fins.
- Identify cleaning materials that are/may be used.
- Describe method of water proofing and checking electrical components.
- Wipe oil, etc., from fan blades.
- Measure temperature drop across evaporator and calculate temperature differential. Determine if with acceptable range (20 degree F). (May be orientation)
- Identify safety considerations.

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.06 LOCATE AND REPAIR REFRIGERANT LEAK

---

## PERFORMANCE OBJECTIVE:

Given a room air conditioner unit, gauge manifold and foses, thermometer, vacuum pump, leak detector, wiping cloth, safety goggles, and mechanic's tools as needed; locate and repair a refrigerant leak in a window (room) air conditioner unit. The unit must hold pressure when repaired.

## PERFORMANCE ACTIONS:

17.0601 Disconnect power from unit.

17.0602 Let old refrigerant out. (Install access valve as needed.)

17.0603 Pressurize the system with dry nitrogen.

17.0604 Find leak (Look for oil deposits on coils, tubing, etc.).

17.0605 Let all dry nitrogen or freon out of unit.

17.0606 Fix leak.

17.0607 Pressurize unit with dry nitrogen. Test repair (soldering job) for leak. If satisfactory, let nitrogen out.

17.0608 Pull vacuum on unit to approximately 29.7 inches of vacuum. Stop vacuum pump when mercury has pulled down and hold for 30 seconds to demonstrate that the system is tight.

17.0609 Recharge unit with correct amount of refrigerant.

## PERFORMANCE STANDARDS:

- Locate and repair a refrigerant leak on a window AC unit so that the unit will hold pressure. Meet instructor's standards.

## SUGGESTED INSTRUCTION TIME:

## RELATED TECHNICAL INFORMATION:

- Describe steps in locating refrigerant leak.
- Outline procedures for repair of a leak in a sealed system.
- Describe use of electronic leak detector.
- Describe use of halide leak detector.
- Identify safety considerations.

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.07 REPAIR RESTRICTION IN LINE

---

PERFORMANCE OBJECTIVE:

Given room air conditioner, gauge manifold and hoses, thermometer, vacuum pump, leak detector, wiping cloth, safety goggles, and mechanic's tools; diagnose and repair a restriction in line. Unit must operate properly after repair.

PERFORMANCE ACTIONS:

17.0701 Disconnect power from unit.

17.0702 Remove old refrigerant.

17.0703 Remove line filter or drier.

17.0704 Place cloth over end of tubing. Purge dry nitrogen through system (to blow foreign matter out of line).

17.0705 End purging and replace line filter.

17.0706 Pressurize with dry nitrogen. Check soldered joints for leaks.

17.0707 Evacuate system.

17.0708 Recharge unit with proper amount of refrigerant.

PERFORMANCE STANDARDS:

- Repair restriction in line so that unit operates properly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Identifying/diagnosing restriction in line.
- Use of dry nitrogen in servicing.
- Evacuating/charging system.

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

## TASK 17.08 CHANGE INOPERATIVE COMPRESSOR

---

PERFORMANCE OBJECTIVE:

Given room AC unit, gauge manifold set, thermometer, vacuum pump, leak detector, safety goggles, wiping cloth, mechanic's tools and equipment, and other materials needed; diagnose inoperative compressor. Reapired unit must operate satisfactorily and performance must be to the instructor's standards.

PERFORMANCE ACTIONS:

17.0801 Disconnect unit.

17.0802 Release old refrigerant.

17.0803 Remove oil line filter: Purge dry nitrogen through lines (catch old oil in lines).

17.0804 Unsolder suction line and discharge line from old compressor: Remove compressor mounting nuts: Lift old compressor from unit.

17.0805 Mount new compressor in unit: Solder line; Install gauge manifold.

17.0806 Install new line filter dryer in unit.

17.0807 Pressurize unit with dry nitrogen: Test for leaks. (If no leaks, release dry nitrogen.)

17.0808 Evacuate unit.

17.0809 Charge unit with correct amount of refrigerant.

PERFORMANCE STANDARDS:

- Diagnose and change inoperative compressor, in room AC unit so that it functions satisfactorily. Performance must be to instructor's standards.

SUGGESTED INSTRUCTION TIME:

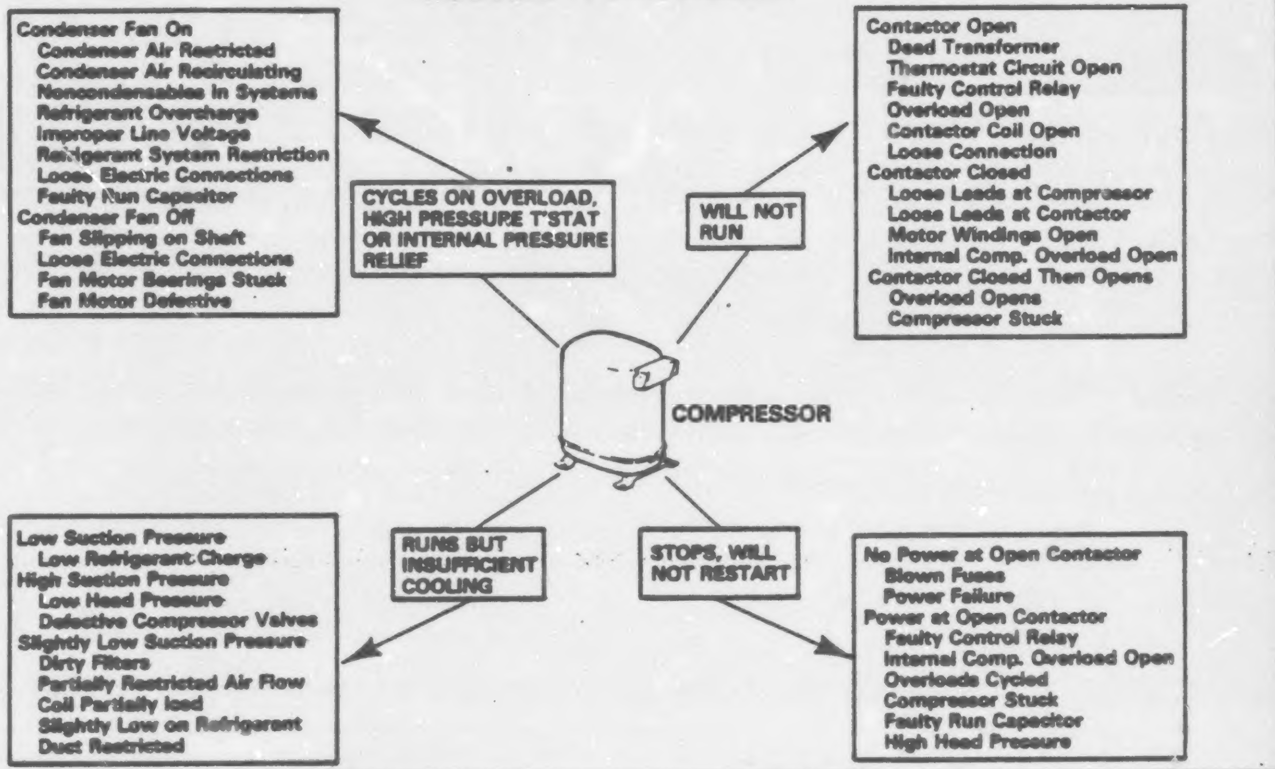
REALTED TECHNICAL INFORMATION:

- Diagnose compressor trouble using "troubleshooting chart".
- Use of tools and instruments and test equipment.
- Repairing tubing.
- Evacuating/charging system.
- Use of dry nitrogen in servicing.

ADDENDUM PAGE ACCOMPANIES THIS TASK PAGE:

- "Troubleshooting Chart".

## TROUBLESHOOTING CHART



**CYCLES ON OVERLOAD, HIGH PRESSURE T'STAT OR INTERNAL PRESSURE RELIEF**

- Condenser Fan On
  - Condenser Air Restricted
  - Condenser Air Recirculating
  - Noncondensables in Systems
  - Refrigerant Overcharge
  - Improper Line Voltage
  - Refrigerant System Restriction
  - Loose Electric Connections
  - Faulty Run Capacitor
- Condenser Fan Off
  - Fan Slipping on Shaft
  - Loose Electric Connections
  - Fan Motor Bearings Stuck
  - Fan Motor Defective

**WILL NOT RUN**

- Contactor Open
  - Dead Transformer
  - Thermostat Circuit Open
  - Faulty Control Relay
  - Overload Open
  - Contactor Coil Open
  - Loose Connection
- Contactor Closed
  - Loose Leads at Compressor
  - Loose Leads at Contactor
  - Motor Windings Open
  - Internal Comp. Overload Open
- Contactor Closed Then Opens
  - Overload Opens
  - Compressor Stuck

**RUNS BUT INSUFFICIENT COOLING**

- Low Suction Pressure
  - Low Refrigerant Charge
- High Suction Pressure
  - Low Head Pressure
  - Defective Compressor Valves
- Slightly Low Suction Pressure
  - Dirty Filters
  - Partially Restricted Air Flow
  - Coil Partially Iced
  - Slightly Low on Refrigerant
  - Duct Restricted

**STOPS, WILL NOT RESTART**

- No Power at Open Contactor
  - Blown Fuses
  - Power Failure
- Power at Open Contactor
  - Faulty Control Relay
  - Internal Comp. Overload Open
  - Overloads Cycled
  - Compressor Stuck
  - Faulty Run Capacitor
  - High Head Pressure

BEST COPY AVAILABLE

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

## TASK 17.09 REMOVE AND REPLACE FAN MOTOR

---

PERFORMANCE OBJECTIVE:

Given room air conditioner, mechanic's tools and all necessary materials; remove and replace a fan motor. The replaced fan motor will run in the correct direction, the blades will not strike any metal, the electrical connections will be tight and secure, and the unit will operate satisfactorily.

PERFORMANCE ACTIONS:

(NOTE: It is impossible to give step-by-step procedures on how to change motors of every make and model used in room AC units. The following steps are basic to represent typical procedure.)

17.0901 Obtain replacement motor.

17.0902 Disconnect power.

17.0903 As appropriate, remove unit from window/wall.

17.0904 Remove cover.

17.0905 Remove fan blades. Wipe blades clean of oil, etc.

17.0906 Remove electrical connections.

17.0907 Remove fan motor.

17.0708 Install new fan notor.

17.0909 Install fan blades.

17.0910 Install wiring.

17.0911 Replace cover and mount unit in window/wall.

17.0912 Test unit.

PERFORMANCE STANDARDS:

- Remove and replace a fan motor in a given room AC unit so that the motor turns in the correct direction, the blades do not strike any metal, and the electrical connections are tight and waterproof. Performance must be to instructor's standards.

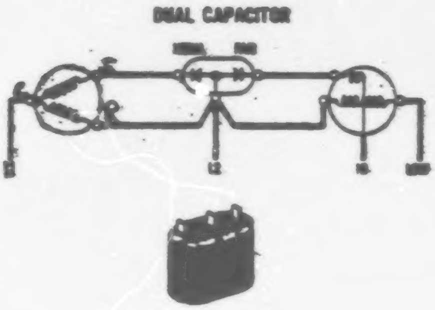
SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain procedures for removal of fan motor.
- Describe methods of removing fan blade from "rusty shaft".

RELATED TECHNICAL INFORMATION (Con't.):

- Explain benefit of cleaning fan blades of oil, etc.
- Describe correct method of wiring a motor.
- Identify different types of fan motors:
  - a. shaded pole
  - b. P.S.C.
    - (1) one speed P.S.C.
    - (2) two speed P.S.C.
    - (3) three speed P.S.C.
- Explain differences between blade and aquirrel-cage fans.
- Explain how to waterproof wiring.
- Identify safety considerations.
- Identify common, run, and start wires of a motor.
- Identify LO and HI sppeed wires of a motor (If both are connected to electrical power at same time, motor will burn up.).
- Identify P.S.C. motor capacitor (3-5 M.F.D. usually):
  - a. Ohmmeter test indicates only shorts or opens, not capacitance.
  - b. Replace capacitors suspected of being faulty.
  - c. Identify dual capacitors found in some units:



Dual capacitors are found on some units. There are two capacitors in one body with three terminal connections marked "herm.," "C," and "Fan." The P.S.C. compressor is connected to the herm. (for hermetic) terminal. The fan motor lead is attached to "Fan." The L2 line to both motors attached to "C" or "Common." One capacitor unit serves both motors.

TASK 17.10

CHECK ELECTRICAL SYSTEM OF ROOM AC UNIT COMPRESSOR

---

PERFORMANCE OBJECTIVE:

Given room AC unit, mechanic's tools, ohmmeter, and unit diagram/schematic (or make drawing of electrical connections); check out electrical system of compressor.

PERFORMANCE ACTIONS:

17.1001 Disconnect power.

17.1002 Remove wires from compressor terminals.

17.1003 Set ohmmeter on high range. Zero meter.

(OPEN CIRCUIT CHECK)

17.1004 Check from common to start for continuity.

17.1005 Check from common to run for continuity.

17.1006 Check from start to run for continuity.

NOTE: No continuity = open compressor.

(GROUNDED COMPRESSOR CHECK)

17.1007 Clean spot on body of compressor.

17.1008 Touch one lead to one of compressor terminals and touch the other lead to cleaned spot on compressor body.

NOTE: If meter shows continuity = compressor is grounded.

(CHECK FOR SHORTED COMPRESSOR)

17.1009 Determine proper "ohms" (resistance) reading (from service manual or experience).

17.1010 Check ohms reading from start terminal to run terminal and from common to run terminals.

NOTE: If ohm reading does not correspond to factory recommendation, compressor is shorted.

PERFORMANCE STANDARDS:

- Check electrical system of room AC unit compressor. Check for open compressor, shorted compressor, and grounded compressor using ohmmeter. Procedures must be acceptable to instructor.

TASK 17.10 CHECK ELECTRICAL SYSTEM OF ROOM AC UNIT COMPRESSOR (Con't.)

SUGGESTED INSTRUCTION TIME:

REALTED TECHNCIAL INFORMATION:

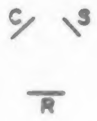
- Use on Ohmmeter.
- Identification of compressor terminals.

TASK EXPANSION:

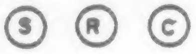
(CHECK A STUCK COMPRESSOR)

1. Disconnect unit.
2. Remove all wires from compressor.
3. Use analyzer to check compressor.
   NOTE: If compressor does not start with analyzer, compressor is stuck.
4. Reverse direction of compressor to possibly free it.
5. Recheck compressor with analyzer.

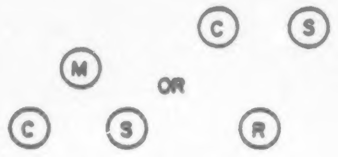
POSSIBLE TERMINAL ARRANGEMENTS OF TYPICAL COMPRESSORS:



COPELAND

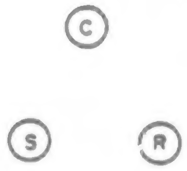


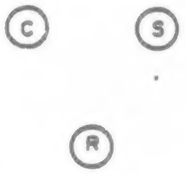
BENDIX-WESTHOUSE

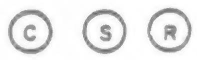


WHIRLPOOL

Tecumseh compressor is always C.S.R. from left to right, up and down, like reading a book. Here are some more arrangements.







UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.11 REWIRE WINDOW AC UNIT

---

PERFORMANCE OBJECTIVE:

Given a room air conditioning unit, access to proper tools and materials, rewire a window air conditioning unit correctly according ot the wiring diagram provided. The rewired unit must operate properly (electrically).

PERFORMANCE ACTIONS:

17.1101 Review diagram of electrical circuit.

17.1102 If no circuit diagram is available, sketch a diagram of the existing circuit.

17.1103 Note where new wiring will be installed.

17.1104 Check wiring diagram to ensure modifications have not been made that would make the unit inoperative.

17.1105 Disconnect electricity and remove wiring that must be replaced.

17.1106 Install new wiring.

17.1107 Check wiring insulation and waterproofing.

17.1108 Connect electricity and test unit operation.

PERFORMANCE STANDARDS:

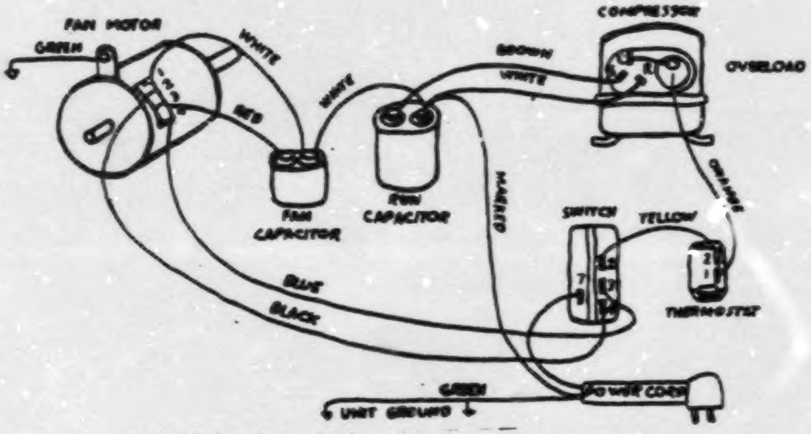
- Wire room AC unit as needed so unit operates properly.

SUGGESTED INSTRUCTION TIME:

REALTED TECHNICAL INFORMATION:

- Interpret wiring diagram, electrical symbols.
- Trace wiring in unit from wiring diagram; identify terminals.
- Determine operating sequence of unit.
- Explain method and procedure for using ohmmeter.
- Identify electrical components.
- Describe/demonstrate methods of makeing electrical connections.
- Identify safety considerations.

## TYPICAL ELECTRICAL CIRUCIT OF A ROOM AC UNIT:


FAN MOTOR
GREEN
WHITE
RED
WHITE
FAN CAPACITOR
RUN CAPACITOR
COMPRESSOR
BROWN
WHITE
OVERLOAD
MARKED
ORANGE
SWITCH
YELLOW
7
2
1
THERMOSTAT
BLUE
BLACK
GREEN
POWER CORD
UNIT GROUND

TASK 17.12 TEST SELECTOR AND FAN SWITCHES

---

PERFORMANCE OBJECTIVE:

On a given window air conditioning unit test the condition of the selector switch using the tools, ohmmeter and materials supplied. The condition will be either open, shorted, or not sequenced correctly.

PERFORMANCE ACTIONS: (Actions for selector switch)

17.1201 Make a diagram of switch circuit if no diagram is available.

17.1202 Disconnect power.

17.1203 Locate off position on switch. Connect one lead of ohmmeter on line terminal. Check for continuity to all terminals.
NOTE: No continuity = switch is in OFF position.

17.1204 Check different positions on switch.
NOTE: No continuity = bad switch (open).

17.1205 Check switch for open and shorts.

PERFORMANCE STANDARDS:

- Test selector switch and fan speed switch/control of given room air conditioner unit to determine if switch is open, shorted, or not sequenced correctly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Measure resistance with ohmmeter.
- Determine location of selector switch.
- Determine sequence of operation of window unit.
- Explain relevant safety precautions.
- Orientation to variable (infinite) spped fan control.

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.13 CHECK THERMOSTAT

---

PERFORMANCE OBJECTIVE:

Given an ohmmeter, mechanic's tools, thermometer, ice water, and room AC unit or thermostat from room AC unit; check thermostat.

PERFORMANCE ACTIONS:

17.1301 Disconnect thermostat if in unit.

17.1302 Disconnect wire from thermostat and check for continuity across switch.

17.1303 Position thermostat in noraml position and place bulb in ice water. Check if switch opens.

17.1304 Attach thermometer to bulb and put them in cold air (from another AC unit) to determine at what temperature the thermostat cuts off.

17.1305 Put bulb in warm water to determine at what temperature the points make.

PERFORMANCE STANDARDS:

- Check thermostat using ohmmeter, cold air, ice water, and warm water. Malfunctioning thermostat must be detected.

SUGGESTED INSTRUCTION TIME:

REALTED TECHNICAL INFORMATION:

- Operation and design of thermostats.
- Use of ohmmeter.

TASK EXPANSION #1:

(CHECK ANTI-ICE CONTROL)

1. Check ice control for continuity. At room temperature, switch should be closed. (Open switch should be changed.)
2. Determine if switch will open by exposing it to 28 degree F or below. Switch should open. (If switch does not open, replace it.)

TASK EXPANSION #2:

(CHECK OUT REVERSING VALVE IN HEAT PUMP UNIT)

1. Place thermostat in heating position.
2. Check to see if solenoid is energized. (Check voltage at coil.) Voltage at coil but solenoid not energized = bad coil. (If not possible to change coil, replace reversing valve.)

TASK 17.14 INSTALL A HARD START KIT

---

PERFORMANCE OBJECTIVE:

Given a window air conditioning unit and access to proper tools, install a hard start kit so that the AC compressor unit will start properly.

PERFORMANCE ACTIONS: "See instructions with Hard Start Kit."

PERFORMANCE STANDARDS:

- Install a hard start kit so a AC compressor unit will start properly.

SUGGESTED INSTRUCTION TIME:

RELATED TECHNICAL INFORMATION:

- Explain purpose of hard start kit.
- Identify components of a hard start kit.
- Describe procedure for wiring a CSR motor.
- Identify safety considerations.
- Identify capacitor start-capacitor run motor.

UNIT 17.0 ROOM/WINDOW AIR CONDITIONERS

TASK 17.15 TROUBLESHOOT WINDOW UNIT

---

PERFORMANCE OBJECTIVE:

Given a window air conditioner, customer complaint concerning operation of unit, AC mechanic's tools and equipment as needed, test instruments, supplies, and replacement parts as needed; troubleshoot the window unit and restore it to service.

PERFORMANCE ACITONS:

17.1501 Observe window air conditioner operation. Review service manual, if available.

17.1502 Test external circuit:
- a. Power
- b. Thermostat
- c. Relay
- d. Capacitors
- e. Overload protectors
- f. Motor compressor
- g. filter
- h. air flow

17.1503 Install gauges and test for leaks (wear goggles).

17.1504 Run unit for about 15 minutes. Oil fan motors.

17.1505 Check unit for frosting or weating down suction line (overcharge).

17.1506 Check if unit is starved (Screen or drier may be partially clogged with moisture or dirt. Check for undercharged unit.).

17.1507 Repair what is necessary:
- a. Remove refrigerant.
- b. Replace worn parts.
- c. Assemble unit.
- d. Evacuate air, charge, and test for leaks.

17.1508 Remove gauge manifold and valve adaptor.

17.1509 Test unit for 15 minutes to ensure proper operation.

PERFORMANCE STANDARDS:

- Troubleshoot given window air conditioner to correct problem experienced by customer. Remove and replace parts that are worn. Charge system after repairs. Test unit. Procedures and performance must be to the instructor's standards.

SUGGESTED INSTRUCTION TIME:

TASK 17.15 TROUBLESHOOT WINDOW UNIT

---

RELATED TECHNICAL INFORMATION:

- Use of hand tools.
- Use of VOM, leak detector, ammeter, manifold gauge set.
- Procedures for testing a window AC system.
- Procedures for evacuating and charging systems.

TROUBLESHOOTING CHART ACCOMPANIES THIS TASK.

Addendum To Task 17.15

# TROUBLESHOOT WINDOW AIR CONDITIONER WORKSHEET

WINDOW UNIT:

Make: ____________________ Model: ______________ Serial # __________
Year: ____________________ Volts: ______________ Amps: __________

| | At Beginning | After 15 Minutes | After Repair |
|---|---|---|---|
| Low-side Pressure | | | |
| High-side Pressure | | | |
| Suction Line Temp.* | | | |
| Liquid Line Temp.* | | | |
| Evaporator Air Temp.* | | | |
| Noise: Compressor | | | |
| Motor | | | |
| EER | | | |

* - Approximate Values

Student: ______________________________ Date: ______________

## TROUBLESHOOTING CHART - ROOM AIR CONDITIONERS UNIT

| TROUBLE | PROBABLE CAUSE | REMEDY |
|---|---|---|
| UNIT DOES NOT RUN | -Power failure | 1. Check power source<br>2. Check outlet for no low voltage using VOM<br>3. Check fuse or breaker |
| | -Low volatge | 1. Check outlet with VOM (should be no less than 10%)<br>2. If circuit is overloaded, reduce load or install separate circuit |
| | -Defective service cord | Replace service cord |
| | -Switch | Replace switch |
| | -Blown fuse | Replace fuse: Determine why fuse failed |
| COMPRESSOR DOES NOT RUN | -Defective overload | Replace overload |
| | -Faulty wiring | 1. Check wire from switch to compressor terminals<br>2. Replace any broken wire |
| | -Loose terminals | Replace compressor |
| | -Defective compressor | Check for open, grounded, stuck, shorted capacitor |
| | -Defective relay or starting capacitor | Replace relay or starting capacitor, as needed |
| | -Bad compressor terminal or switch | Replace switch |
| | -Defective thermostat | Replace thermostat |
| | -Improper hook-up | Check wiring diagram. Determine proper wiring for common, start, and run with VOM |
| | -Open running capacitor | Replace capacitor |

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| CONTINUOUS RUNNING, BUT COOLING | -Thermostat stuck | Replace thermostat |
| | -Unit to small for room | Calculate heat load of room: Replace with proper size unit |
| CONTINUOUS RUNNING, NOT COOLING | -Improper charge of Freon | Check for leaks and recharge |
| | -Restricted air flow | Remove all obstacles from condenser, for proper ventilation |
| | -Dirty condenser | Clean out condenser |
| | -Compressor not pumping | Check compressor for inefficiency: Replace as necessary |
| | -Freon restriction | Replace strainer or filter drier |
| EVAPORATOR | -Dirty blower | Clean blower |
| | -Dirty filter | Clean filter |
| | -Slightly under charge | Check back pressure: Find leak: Repair |
| | -Thermostat set to cold | Adjust thermostat |
| | -Fan running to slow | 1. Check fan motor running capacitor<br>2. Check fan motor bearing |
| FAN MOTOR DOES NOT RUN | -Open windings | Replace notor |
| | -Bad capacitor | Replace capacitor |
| | -Bad fan terminal on switch | Replace switch |
| | -Bad bearings | Replace motor or have it repaired |
| | -Jammed fan blade | Adjust fan blade |
| | -Improper hook-up | Check diagram for proper hook-up |

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|---|---|---|
| WATER LEAKING IN HOUSE | -Unit not correctly tilted | Tilt unit 1/4 inch lower to outside |
| | -Drain line stopped up | Unstop drain line |
| HEAT PUMP WILL NOT SWITCH OVER | -Bad thermostat | Check thermostat for continuity between heating contact points: If points not closed, replace thermostat |
| | -Bad solenoid | Check coil continuity: Replace if open |
| | -Stuck reversing valve | Check voltage at coil and coil continuity: If OK,check for stuck valve: Replace reversing valve |
| NOISE IN UNIT | -Bad rubber grommit | Replace |
| | -Loose mounting bolt | Tighten |
| | -Mounting bolt to tight | Loosen |